A SYSTEMS ANALYSIS OF
HUMAN RELATIONS

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A SYSTEMS ANALYSIS OF HUMAN RELATIONS

By

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A THESIS

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A Systems Analysis of Human Relations. (June 1971)
Abstract of a Master's Thesis at the University of Miami. Thesis supervised by Professor Bernard E. Howard.

This thesis demonstrates the feasibility of studying human relations by the techniques of Systems Analysis and Computer Simulation. Two simple models are developed: one, a discrete system using a finite state automaton as a model; two, a continuous model analyzed by phase space analysis. Computer simulation experiments are conducted using these models. The results are interpreted in terms of observable human behavior patterns.

Sociocybernetics is a new field in which cybernetic principles are applied to a system analysis of social structures. The concepts and techniques are applicable to the fields of psychology, sociology, human ecology, human relations, cybernetics and systems analysis.

ACKNOWLEDGEMENTS

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The author's family deserves a special thanks for quietly letting their home fill up with green and white computer printout sheets without complaint.

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1. INTRODUCTION

The purpose of this thesis is to demonstrate the feasibility of studying human relations by the techniques of Systems Analysis and Computer Simulation.[1] Two simple models are developed. Computer simulation experiments are conducted using the models. The results are interpreted in terms of observed human behavior patterns.

Human relations applies to the interaction of persons in a variety of encounters. Sociocybernetics is the application of cybernetic principles to a systems analysis of social structures. The GENESIS MODEL is a computer simulation of Human Relations.

THE PROBLEM

The problem which originally interested the author was the control of strife as a necessity for survival. The study of strife or of any other factor which produces entropy within the human social system must include some model which can be subjected to a systems analysis. The model should be capable of simulation before the event occurs, that is, in the real time.

THE PROCEDURE

The procedure, SOCIOCYBERNETICS, is a systems approach, applying cybernetic principles to social organization. Essentially this technique

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[1] For customary background review of the literature, read Appendix A first.

is a bridge between the analytical tools of the physical scientist and the concerns of the behaviorial scientist.

"Simulation is a technique for conducting experiments on a computer which involves certain types of mathematical and logical models that describe the behavior of a system (or some component thereof) over extended periods of time."[2]

THE EXPERIMENTS

Two models are developed for experimental analysis:

a) A discrete System: GENESIS MODEL ONE

b) A continuous System: GENESIS MODEL TWO

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[2]Skramstad, Harold K., "Computer Simulation Models," unpublished Industrial Engineering 572 class notes, University of Miami, Spring 1970.

2. EXPERIMENT ONE: THE DISCRETE MODEL

The System Analysis of Human Relations which suggests the new subject of SOCIOCYBERNETICS, has resulted in the design of a computer simulation model of human interaction. The model has a name: GENESIS which could mean either "first model" or "GENeral Environmental Simulation In Society."

Postulates concerning human relations used in the design are:[3]

POSTULATE ONE: The interaction of human beings is describable as a dynamic system. That is, Human Relations is a function of the nature of each person, the way in which persons are interrelated, the initial condition of each person and the kinds of inputs into the system.

POSTULATE TWO: A finite state automaton is the model of the human. The simplest meaningful model includes two internal states and two external states. Let us say that a person could be either "happy" or "sad" and that he can perceive his environment as either "good" or "bad."

Much of life is in terms of a two-state feeling or response. "How do you feel?" "OK" or "Not so good." What sort of review did the new movie receive, "favorable" or "unfavorable." And on to the rather ultimate question: "Alive?", "Dead?" Admittedly there may be many shades of feelings and perceptions, but in the first model by using only two states such as "happy" and "sad", there is no loss of generality in

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[3]A detailed description of the Discrete Model is included in Appendix B.

principle; subsequent refinements of the model can provide for as many gradations of feeling as desired within the present theory.

The next fact to which we address ourselves is how a person responds to a given input and what sort of output he gives. The model design allows for all possible combinations within its parameters.

From the definition of a finite state automaton, a person's behavior is describable by a pair of matrices; an example is Table 1.

Table 1

THE MAN

STATE \ INPUT	GOOD	POOR
HAPPY	+1	+1
SAD	+1	-1

OUTPUT

STATE \ INPUT	GOOD	POOR
HAPPY	+1	-1
SAD	-1	-1

NEW STATE

The above model says in effect that, for instance, if the person is in a happy internal state, and is in a good environment, that he will move into a happy next state and give off a good response to the other person. Or for instance, if at this moment in time he is in a sad internal state and is receiving a good input from his environment, he will give a positive output but will move into a sad internal state. This might describe a person who is "laughing on the outside but crying on the inside." He makes a continual effort to give off good outputs, vibrations, even under adverse conditions, but it takes something out of him and he tends more often to be inwardly saddened.

Designing a man then becomes a process of determining how he gives outputs under certain conditions and how he moves into his next state. Essentially this is done by placing plus one or minus one in each of the four cells in each of the two matrices. A person may conceivably have all pluses and be a complete "manic" individual; another may conceivably have all minuses, and thus be completely "catatonic." There are 256 different combinations possible in this design.

POSTULATE THREE: <u>The interconnections between persons can be described by a connection matrix.</u>

The model, while any arrangement is possible, assumes that the total output of the woman is perceived by the man as his input and vice versa.

NUMBER OF SYSTEMS POSSIBLE

(Designs of Man) X (Designs of Woamn): 256 X 256 = 65,536

This simplest of models thus allows for a surprising diversity of behavior.

THE SYSTEM INPUT

In the first simulations we are assuming no input. Rather, the system is a function of its initial conditions. We could look at it this way: The wife has had a certain kind of day--maybe a good one (she won the rubber at afternoon bridge); or a bad day (the waterbed sprung a leak just after lunch). Her husband has had a good day at the office or it was one of those hectic days. The husband comes into the house shuts the door. He and his wife now interact, each bringing as his initial condition the way things are at that moment. The door is shut, the doorbell is disconnected, as is the telephone and the TV: i.e., there are no inputs. What happens? In their black box the simulation proceeds.

There are 16 possible starting conditions, ranging from both persons having a bad environment and a sad feeling to both having a good environment and feeling happy.

EXPERIMENT 1-A

TWO PERSONS SIMULATION OF A MAN AND WOMAN

The simulation of a two person system with the man as already described, and with a woman who tends to complain quite often but is feeling happy after her fussing as shown in Table 2, is analyzed here.

Table 2

THE WOMAN

STATE \ INPUT	GOOD	POOR
HAPPY	+1	-1
SAD	-1	-1

OUTPUT

STATE \ INPUT	GOOD	POOR
HAPPY	+1	+1
SAD	+1	-1

NEW STATE

The simulation is run for all different sixteen Initial Conditions.[4] One can make the following interpretations:

1. Whether relationship reaches a steady state, or results in a cycle, and thus in a given time period, repeats itself.[5]
2. Other measurements are
   a. The Strife Index[5] of the system.
   b. Whether or not the resultant from any given initial condition results in an acceptable or unacceptable state, and the fractional total of acceptable states.

The strife index takes into account both internal states and outputs; the acceptability index takes into account only internal states.

Inferences that one can draw from this simulation indicate a strife index which is low enough so that there could possibly be a large number of acceptable situations; for acceptability of a system occurs when both persons feel happy more than half of the time. However, there is only one possible initial condition in this simulation whose results are acceptable, the steady state that results if both persons start in a good mood and in a good environment. Only from this initial condition does the man feel "Happy". His efforts to input good feelings into his wife are apparently successful because the simulation results indicate she always feels happy. Given the design of these two persons the result is a feasible description of the relations between these two humans. The person who "lets off steam" may feel good afterward and the person who at some personal effort tries to put forth good feelings, may tend more often to feel sad afterward. How much does it cost one to put on a brave front?

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[4]See Appendix B-7 for computer output.

[5]See Appendix B-2 for method of output result computations, such as, definition of Strife Index.

EXPERIMENT 1-B

AN EXAMPLE OF THE MODEL APPLIED TO COUNSELING

Average Andy is in love with six girls. Whom should he marry? A simulation is made of possible results. Andy's friends are described below from a computer printout of their personality matrices.

ADORABLE ANNIE, because she is just like Andy, responds in a normal way to each situation.

Table 3

ADORABLE ANNIE

STATE \ INPUT	GOOD	POOR
HAPPY	1	1
SAD	-1	-1

OUTPUT

STATE \ INPUT	GOOD	POOR
HAPPY	1	1
SAD	-1	-1

NEW STATE

ECCENTRIC ELLEN, interesting because she is exactly opposite to Andy.

Table 4

ECCENTRIC ELLEN

STATE \ INPUT	GOOD	POOR
HAPPY	-1	-1
SAD	1	1

OUTPUT

STATE \ INPUT	GOOD	POOR
HAPPY	-1	-1
SAD	1	1

NEW STATE

HAPPY HELEN tends most often to be in a happy state.

Table 5

HAPPY HELEN

STATE \ INPUT	GOOD	POOR
HAPPY	1	1
SAD	-1	-1

STATE \ INPUT	GOOD	POOR
HAPPY	1	1
SAD	1	-1

SAD SADIE carries too many worries and most often is sad.

Table 6

SAD SADIE

STATE \ INPUT	GOOD	POOR
HAPPY	1	1
SAD	-1	-1

OUTPUT

STATE \ INPUT	GOOD	POOR
HAPPY	1	-1
SAD	-1	-1

NEW STATE

BUBBLY BETTY gives out a lot of good output.

Table 7

BUBBLY BETTY

STATE \ INPUT	GOOD	POOR
HAPPY	1	1
SAD	1	-1

OUTPUT

STATE \ INPUT	GOOD	POOR
HAPPY	1	1
SAD	-1	-1

NEW STATE

GRUMPY GERTRUDE does a lot of nagging.

Table 8

GRUMPY GERTRUDE

STATE \ INPUT	GOOD	POOR
HAPPY	1	-1
SAD	-1	-1

OUTPUT

STATE \ INPUT	GOOD	POOR
HAPPY	1	1
SAD	-1	-1

NEW STATE

Table 9

SIMULATION ANALYSIS FOR AVERAGE ANDY'S GIRL FRIENDS

GIRL	SYSTEM STRIFE (smaller the better)	NUMBER OF ACCEPTABLE INITIAL CONDITIONS	ACCEPTABILITY INDEX (larger the better)
Adorable Annie	.500	4	.250
Eccentric Ellen	.500	0	0
Happy Helen	.313	8	.500
Sad Sadie	.688	2	.125
Bubbly Betty	.438	4	.250
Grumpy Gertrude	.563	4	.250

Of course, contrary to the common assumption that in marriage one will make over his (or her) partner, we have assumed that this just isn't so. This simple experiment, summarized in Table 9, suggests some facts about life. An old saying is that "opposites attract." This may be true, and though the simulation with Ellen does not produce the most strife-ridden relationship, it has no possibility of being acceptable to both partners at the same time. An analysis of the three relationships which each produce 4 acceptable situations: (a) the one with the least strife is with Betty who tries hardest to give good outputs to Andy; (b) Annie, the girl just like Andy, produces thus a strife of .500; (c) the Strife Index is highest with Grumpy Gertrude even though she has the same Acceptability Index as Betty and Annie. The highest strife situation is with Sad Sadie which indicates that the internal state has the greatest effect on the relationship-- even more so than the output; this is confirmed with the fact that Andy's best bet is to consider Happy Helen, who is not so bubbly as Betty. He doubles his chances for an acceptable marriage because of her positive inner state.

EXPERIMENT 1-C

THE EFFECT OF TRANSFORMATION OF NEGATIVE INTERNAL STATE ELEMENTS AND THE REDUCTION OF STRIFE TO THE ACCEPTABILITY OF A HUMAN RELATION SYSTEM

A model is used which has three states and three environments a; person may be "happy", "neutral" or "sad"; his outputs may be "good", "neutral" or "poor."

In this simulation the Man (Table 10) tends to give off good outputs but he is most often in a sad mood. The woman (Table 11) has a trend of negative outputs, but she has a very happy internal state. We assume that her model is held constant during the simulation.

Table 10

MODEL FOR SAD MAN

ENVIRONMENT

STATE	GOOD	NEUT	POOR
HAPPY	1	1	1
NEUT	1	1	0
SAD	1	0	-1

OUTPUT

ENVIRONMENT

STATE	GOOD	NEUT	POOR
HAPPY	1	0	0
NEUT	0	-1	-1
SAD	-1	-1	-1

NEW STATE

Table 11

MODEL FOR WOMAN

ENVIRONMENT

STATE	GOOD	NEUT	POOR
HAPPY	1	0	-1
NEUT	0	-1	-1
SAD	-1	-1	-1

OUTPUT

ENVIRONMENT

STATE	GOOD	NEUT	POOR
HAPPY	1	1	1
NEUT	1	1	0
SAD	1	0	-1

NEW STATE

Our procedure is: in order, replace each of the man's negative internal states by a neutral condition, until all his negative traces are removed. Then start a process of replacing a neutral internal state by a positive state. There were eight runs of the system for a total 648 simulations. The man moved from 5 negative positions and one positive in his internal state to no negatives and three positives. A sample simulation is illustrated by Table 12.

Table 12

A SAMPLE THREE STATE SIMULATION

INITIAL CONDITION NUMBER: 18

FIRST LINE IS THE INITIAL CONDITION

1	0	-1	-1
0	-1	-1	1
-1	-1	-1	0
-1	0	1	-1
-1	-1	-1	0

THE LAST 2 LINES FORM A CYCLE

UNACCEPTABLE CYCLE

STRIFE INDEX = 0.625

We have used the same measure of strife and acceptability as in the two state system, with simulation results described in Table 13.

Table 13

SIMULATION RESULTS OF STRIFE DECREMENT EXPERIMENT

SYSTEM NUMBER	NUMBER OF MAN'S NEGATIVES	SYSTEM STRIFE	NUMBER ACCEPTABLE SITUATIONS	CYCLES	STEADY STATES
1	5	.414	1	38	43
2	4	.355	1	35	46
3	3	.199	1	14	67
4	2	.131	1	5	76
5	1	.059	1	0	81
6	0	.000	1	0	81
7	add +1	.000	6	0	81
8	add +1	.000	27	0	81

The empirical observation is that as we lower a man's inner negative feelings, there is a steady decrease in the strife level of the system: the number of acceptable situations does not increase with the lowering of strife, when the lowering results from simply moving a person into a "neutral position." Acceptability increases only as there are increasing positive elements.

The suggestions for experimental application and development are richly suggestive here. It would appear obvious that a mere reduction of negative feelings may simply result is a submissive individual in which there is still no positive acceptance of the system results. Of course the implications of this observation in real life are significant. Just to neutralize a relationship, to remove strife, may show a significant lowering of the strife index, with no improvement of the acceptability.. a tranquilized patient or a subservient person may have a low strife index... but is this what really constitutes optimal human relations?

OBSERVATION

The discrete system is feasible as a means of simulating human behavior. The system can be expanded to include more than two states: we have demonstrated this for three states. It can also be expanded to include more than two persons.

Further development could include the important factors of "input" and "self-feedback", which can of course be incorporated in the design of the connection matrix, stochastic inputs and component reactions, etc. In addition, while from a heuristic view the feasibility of the approach is established, an important next step in the analysis would be validation of the model in real life situations.

3. EXPERIMENT TWO: THE CONTINUOUS MODEL

The discrete model, GENESIS ONE, made the assumption that human behavior moved in discrete units of time. The continuous model, GENESIS TWO, makes the alternate assumption that humans move continuously from one condition to another.

The following postulates are made concerning GENESIS TWO:[6]

POSTULATE ONE: The INTERNAL STATE

I-A: A person's mood does not change without a cause. This is the principle of "MOOD INERTIA".

I-B: The internal state, happy or sad, tends to change in the same sense as the input from other person.

Examples: "You catch more flies with honey than vinegar."
"Butter up the boss.", etc.

I-C: The internal state of a person tends to change in the opposite sense of the input from self.

Example: "Blowing off steam sure makes a fellow feel better.", etc.

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[6] See Appendix C-2 for a mathematical discussion of the model.

POSTULATE TWO: The OUTPUT

II-A: The output tends to change in the same sense as the internal state.

Example: "A happy mood tends to produce pleasant outputs."

POSTULATE THREE: BOUNDEDNESS

III-A: The person can get just so happy or sad, and give off just so much bad or good feelings. That is, all variables are bounded, which for simplicity we normalize to # → ±1.

The continuous model consists of two persons, each of whom is described by two differential equations, one for his internal state (happy-sad) and one for his outputs (good-bad). These equations are:

$$S'_m = (-a_{12}\theta_m + a_{14}\theta_f)(1 - S_m^2)$$

$$\theta'_m = (a_{21}S_m)(1 - \theta_m^2)$$

$$S'_f = (a_{32}\theta_m - a_{34}\theta_f)(1 - S_f^2)$$

$$\theta'_f = (a_{43}S_f)(1 - \theta_f^2)$$

Where:

S_m is the Man's Internal State

θ_m is the Man's Output

S_f is the Woman's Internal State

θ_f is the Woman's Output

' = time derivative

The entire infinite range of possibilities can in a qualitative sense be described by six different couples.

1. A strongly coupled system in which
   a) the man is most dominant (Man's Output has greatest effect on both), or
   b) the woman is most dominant, or
   c) neither is dominant, but each is most effected by the other's output.

2. A weakly coupled system in which
   a) each person is most effected by man's output, or
   b) each person is most effected by woman's output, or
   c) each is most effected by his own output.

The significance of this classification in respect to the numerical values of the a_{ij} is elucidated in Appendices C-6 and C-7. The above system of human relations has been subjected to a phase space analysis (which is described in Appendix C). The Boundedness of the system implies that the entire action takes place within a tesseract, or a four dimensional cube.

Two of the qualitatively different couples have been selected for an analysis.

EXPERIMENT 2-A

SIMULATION WEAKLY COUPLED TWO PERSON SYSTEM

The couple has a weak relationship (the system is weakly coupled) and each is most effected by his own output. For instance, picture a breakfast table. Some sort of conversation is going on. He talks about the results of last night's baseball game as he reads the paper and she chats about the bridge luncheon on today's agenda. If time could stop at a moment and each were asked what the other had said, a rather incomplete response would occur.

To illustrate what takes place in such a system, one might look at the neighborhood of the origin in phase space. At this point, both persons are in a neutral condition. As time progresses the following action takes place: the man starts to move to a happy state, the woman starts to move to a sad state. Graphs illustrate this:

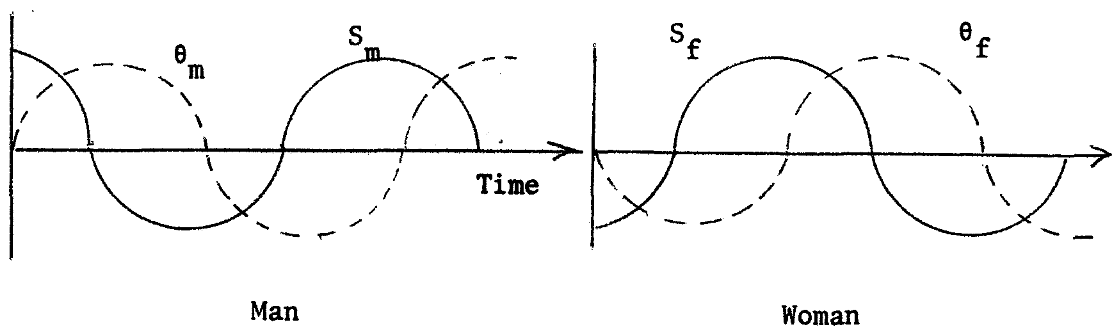

Figure 1 Graphical illustration of a continuous system

In fact this could be pictured as a single graph with all four conditions listed on it. A large analogue computer could be used to make such a print out for every possible quantitative value that would hold for this given situation. However, with the use of phase space analysis, it is not necessary to run all situations, for the analysis will indicate what takes place, over time, for every given initial condition, based on what takes place for certain key, or critical situations.

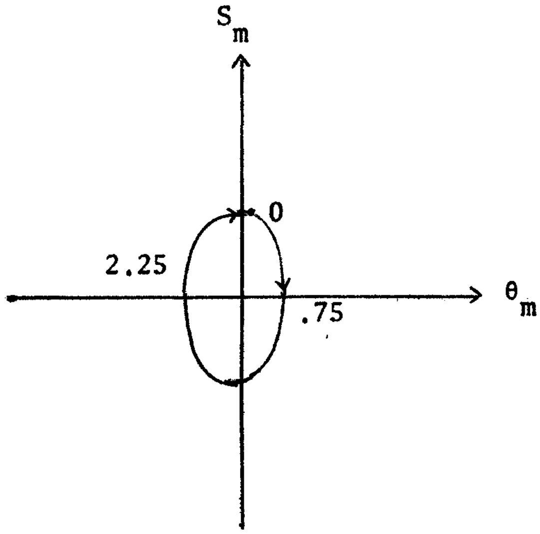

Figure 2-a Male Cycle

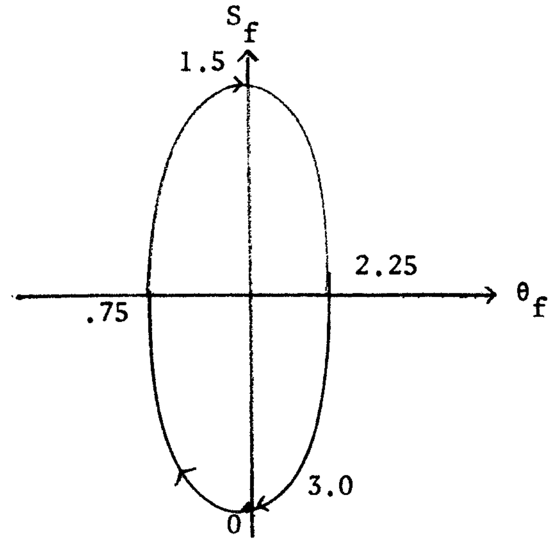

Figure 2-b Female Cycle

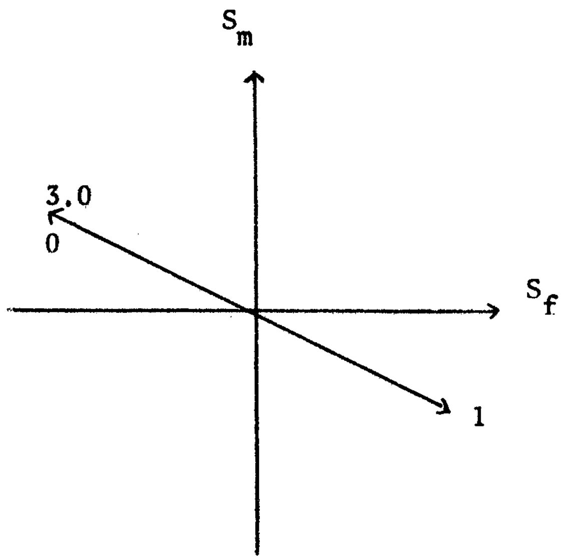

Figure 2-c States Compared

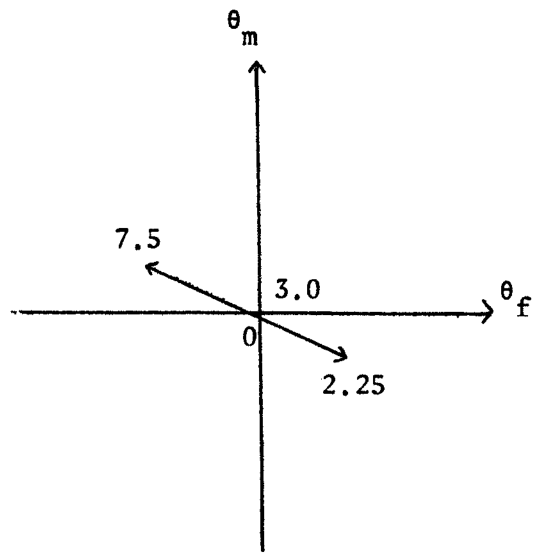

Figure 2-d Outputs Compared

Drawings indicate relative magnitude

Numbers indicate time

Figure 2 A weakly coupled system with each person most affected by his own output. This is Experiment 2-A, Case 3, Appendix C-7, out of phase oscillation of frequency 2 cycles per unit time.

$\lambda = -2i$ and eigenvector = (1,0,-2,0)

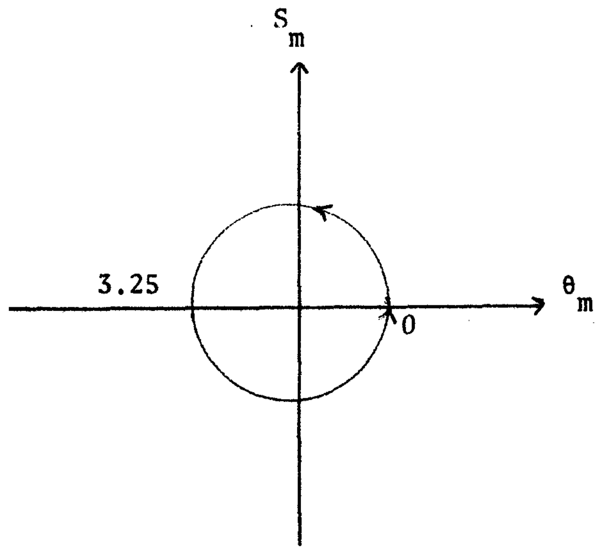

Figure 3-a Male Cycle

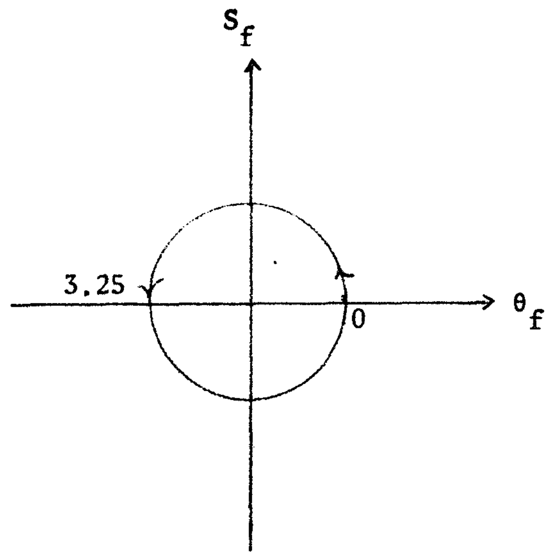

Figure 3-b Female Cycle

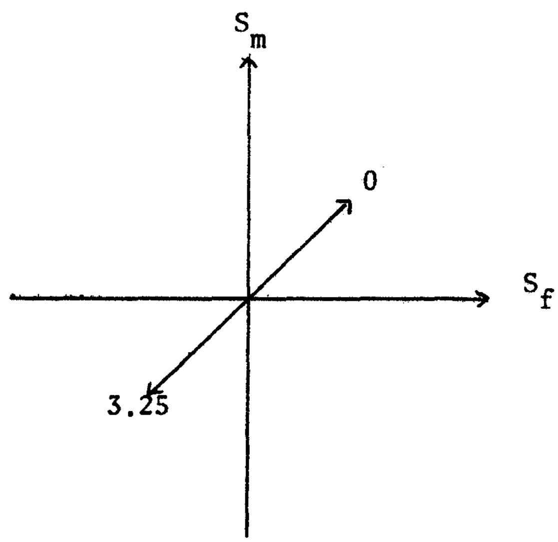

Figure 3-c States Compared

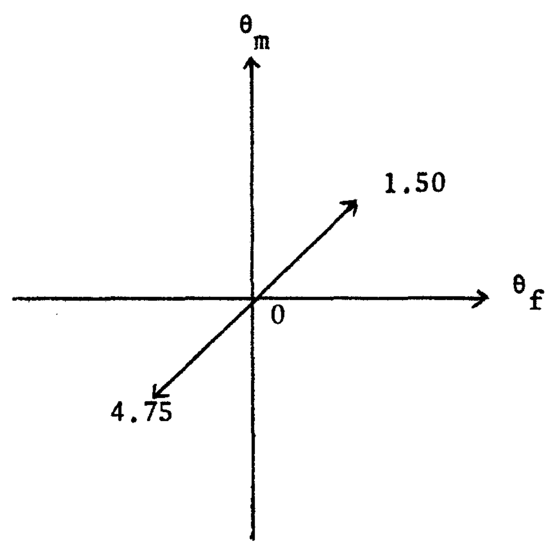

Figure 3-d Outputs Compared

Drawings indicate relative magnitudes
Numbers representing time

Figure 3 A weakly coupled system with each person most affected by his own output. This is Experiment II-1, Case 3, Appendix C-7 within phase oscillation of frequency, 1 cycle per unit time.

$\lambda = -i$ and eigenvector = (1,0,1,0)

Experiment 2-A indicates that an analysis of the action at the origin clearly shows the weak interconnection between the two persons and how each is most effected by his own output.

There are thus two pure modes of behavior in the neighborhood of the origin; one of frequency 2 cycles per unit time, with the persons out-of-phase (one is up while the other is down), and one of frequency 1 cycle per unit time, with the persons in-phase (both up or both down together). All possible complex behavior patterns are different combinations of these two fundamental modes.

EXPERIMENT 2-B

SIMULATION OF A STRONGLY COUPLED SYSTEM

The second (qualitatively distinct) couple that is examined is one in which very strong interrelations exist; it is strongly coupled, with each person most effected by the man's output. One description in classical terms is: the man is extrovert, the woman introvert. Another description is: the man is dominant (the classification is not just qualitative, its quantitative meaning in respect to the numerical values of the a_{ij} is explicated in Appendix C-7). An example of the results of this analysis is shown in Figure 4, and 5.

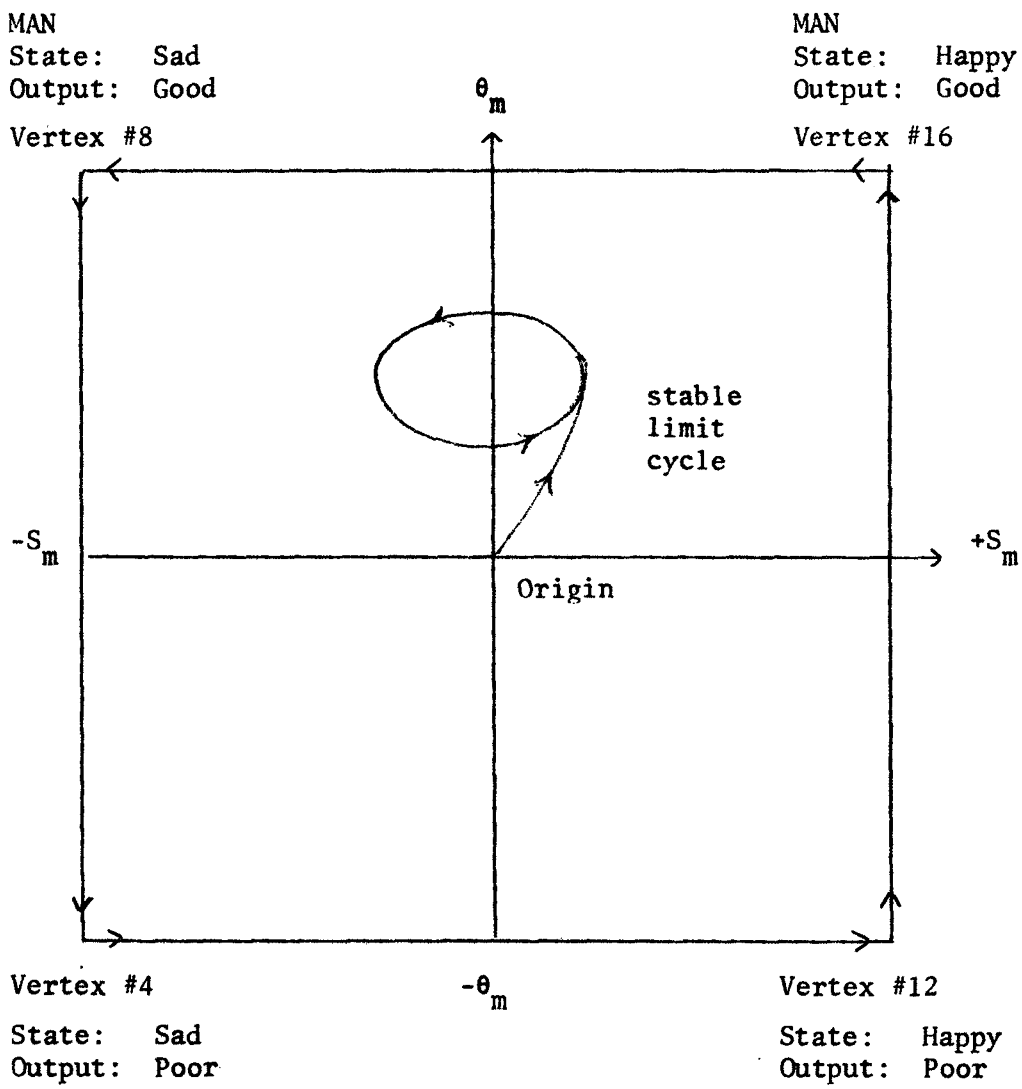

Figure 4

A Strongly Coupled System in neighborhood of origin
Experiment 2 -A;
Each person most effected by Man's Output (Case 1
in Appendix C-7)

The graph illustrates the trajectory of the man where the woman's condition is happy with a good output at each vertex; one system behavior moves away from origin along the unstable eigenvector (1,1,3,3), and into a stable limit cycle for the man in the plane $S_f = 1$, $\theta_f = 1$. See Appendix C-11 for numbering of the vertices of the tesseract.

Each graph in Figure 2 is the plotting of two of the possible states with time as the running parameter. Since it is somewhat difficult to draw four dimensional space in two dimensions, though we do represent three dimensional space of two dimensions, i.e., a sphere, or cone, or cube on a piece of paper, we have to make several graphs to depict all results at one place, overtime. There can be a variety of comparisons, depending upon the results one wishes to study. For instance in Figure 2-a, we note that as time goes on, the man begins with no negative state, but rather rapidly reaches a sad state, though he continues to give out good outputs for a time; then at the bottom point, when the man is as unhappy as he can possibly be, he gives bad outputs, but the more bad outputs he gives, the better he starts to feel "letting off steam" until eventually at time 2.25 he feels neutral and then starts to feel happier, though still giving off bad outputs. This circular pattern continues for the man. A like pattern developes for the woman, though her magnitude of happiness, sadness is different. Figure 2-c indicates that while the man is happy the woman is sad; i.e., the oscillations are out of phase. The oscillatory behaviors for each person are 180° out of phase, as indicated by the straight lines in the second and fourth quadrants.

A weakly coupled system where each is most effected by his own self-feedback could likewise have the following simulations in the neighborhood of the origin, both the man and the woman begin to move into a happy state, each giving off good outputs. The results indicate that now they are in phase; when one is happy, so is the other, and conversely. Figure 3 illustrates the behavior.

We can intrepret the Graph of the Phase Space Analysis, Figure 4, to mean that this is what happens if the woman's initial condition is good and her output is good. The man (if he starts at a completely neutral point), moves into a cycle in which his parameters represent good outputs, and moving in a cycle that is sometimes a happy state and sometimes sad, but never extremely happy or sad. Likewise, one can see what will happen if man starts with any of the possible shades of feeling very good, very sad, giving negative outputs or good ones. The arrows around the bounding edges indicate the limiting pattern of his State and output.

The next example is of the same situation, put in this case the woman is in a negative state and has a good output, Figure 5. The man, contrary to moving into a spiral over time, given enough time will tend to reach a steady state at the origin of the tesseract, which represents a neutral state and output.

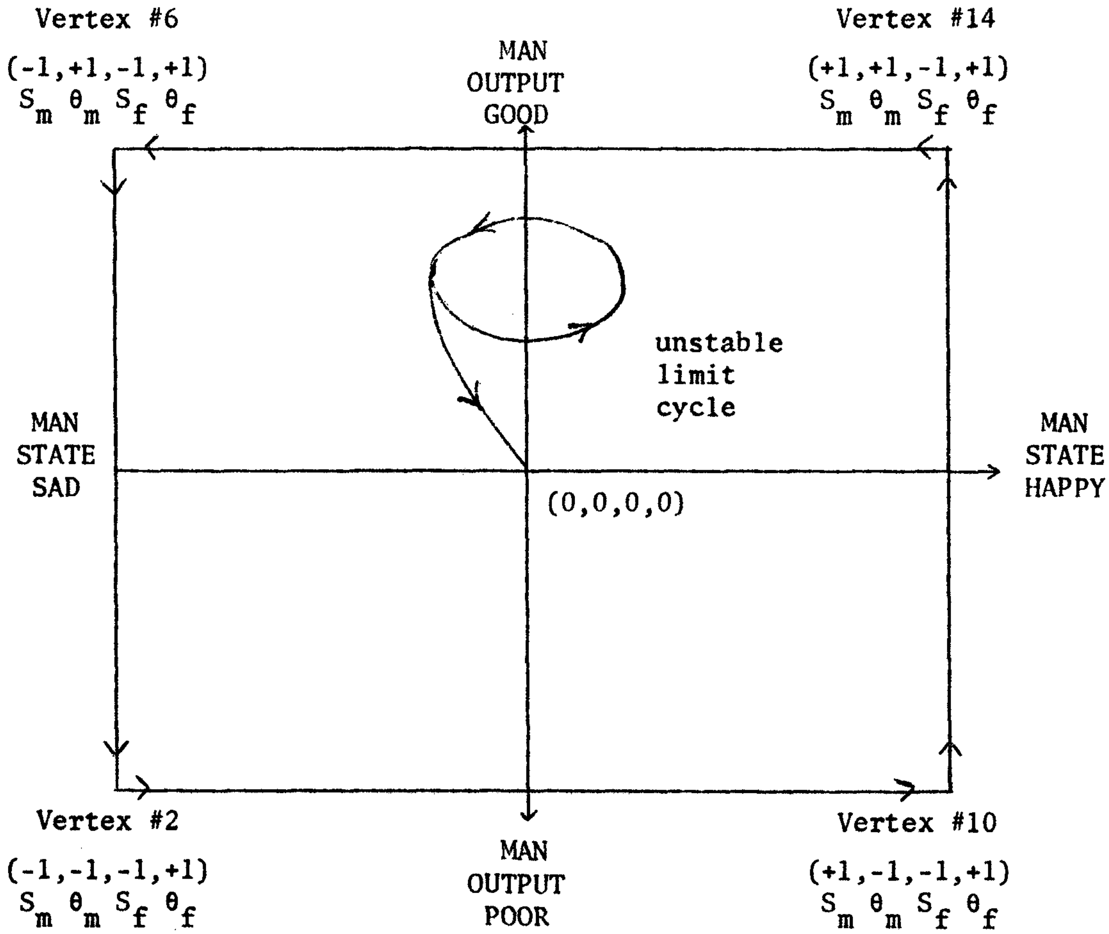

Figure 5

A Strongly Coupled System in neighborhood of origin
Each person most effected by Man's Output (Case 1
in Appendix C-7)
Experiment 2-B.

Figure 5 illustrates the trajectory of the man's state and output with time as the running parameter. The man has an unstable limit cycle in the plane $S_f = -1$, $\theta_f = 1$. Behavior trajectories spiral away from this limit cycle toward the origin, approaching along the stable eigenvecter (-1,1,-3,3).

In like manner, the other qualitative cases can be examined. An entire set of plates can be constructed to show the simulation results. It is only necessary to produce graphs for these cases; because of the nature of phase space analysis, all other cases which include an infinite number of possibilities can have their behavior deduced by use of the proper phase space graphs. In other words, once one has established the fact that a system is, for instance strongly coupled, and one in which the output of the woman (rather than the man) most affects both the man and the woman; the use of the phase space analysis graphs will indicate the behavior of that system when started with any given set of initial conditions.

RESULT OF EXPERIMENT TWO

The phase space analysis demonstrates the feasibility of a systems analysis using computer simulation models of a continuous system for the study of human relations.

4. CONCLUSION

Sociocybernetics, a Systems Analysis using Computer Simulation, is a useful new tool in the analysis of human social relations. The GENESIS MODELS can be expanded to represent with increasing accuracy human relations and expanded to include more than two persons. These are not computer models of a human being; rather we have demonstrated the feasibility of this approach by using plausible models.

Applications of sociocybernetics can be made in the fields of psychology, sociology, management, and human relations. As an example, the phase space analysis procedure could be used as an instrument for the early detection of a disturbed family constellation. The discrete model has possibility as a mangement tool, for example, in the assignment of nursing and physical therapy staff to physically handicapped patients. From the way in which the models were described, the value of such an approach in marriage counseling should be apparent. A predictor display, a sociological thermometer, might be developed which could include the interaction of groups and persons (e.g., poor) to institutional structures (e.g., power). Applications can be made in the area of human ecology.

APPENDIX A

MOTIVATIONAL LITERATURE FOR A SYSTEMS ANALYSIS OF HUMAN RELATIONS

Cybernetic principles, including systems analysis, mathematical models and computer simulation have been used to produce extraordinary achievements in the physical sciences; the atom has been split, and astronauts have walked on the moon. In fact, man's conquest of nature has progressed so far that he is capable of altering the global environment in potentially lethal ways. Man has the technological knowledge to preserve himself and his planet indefinitely, but the fundamental problem in the survival of the race is man himself; our knowledge of, and ability to control, our social interactions in a rational way are so limited that man is an endangered species, and the race of man and his little planet may perish through his own hand before the end of the century.

Mankind's ancient enemies are depicted as the mythical Four Horsemen of the Apocalypse. Strife continues to threaten human life on the planet Earth. The survival of man on earth is dependent upon stabilization of the earth's human community. Stabilization of society and its structures requires control of strife as a prerequisite for man's survival. Strife is a factor that prevents less than optimal development of man and his social environment. Strife is analogous to entropy, which is a measure of amount of energy not available for work during a process. One might note that war is the organized conflict between highly structured large social systems. Strife is the disintegration that occurs within a system. Persons have energy to spend toward realization of their objective. The actual level reached is often less than maximal, for example, strife produces a decrement in human relations. It is our thesis that cybernetic principles which have been so successfully applied in the physical sphere of life can be applied to the crisis of human relations.

These ideas are not entirely new, of course; it is the quantitative implementation of the ideas of many writers in many fields which is believed to be original. For example, Kelley (1968) has developed predictor displays for submarine guidance systems. His approach raises the exciting possibility of developing predictor displays for human relations. The only point at which man can really exercise control is in the future, for the past is gone and the present passes before we can act upon it. The person who predicts can participate in the shaping and control of the future. A predictor display indicates in real time, that is, before the event occurs, the probable outcome of the present course of action. Schwitzgebel (1970) suggests that there can be creative application of control techniques in social situations.

A general systems approach has been applied to many of the physical and environmental problems. Churchman (1969) presents a general description of systems analysis, while Buckley (1969) makes direct application to the behaviorial sciences, Cleland and King (1969) in management sciences and DeGreen (1970) in psychology and human factors engineering. Generally a systems analysis approach in social systems focuses upon the macro-community.

A system analysis uses a model. There is no universal agreement on what kind of model to use in the study of humans. Lorenz (1969), Ardrey (1966), Morris (1969) infer that the best place to study animals is in their natural habitat. The study of man in his natural habitat is difficult so he is brought into a testing cubical, or he is modeled. Rhesus monkeys, pecking birds or rats are sometimes used as models from which inferences may be made about man's socio-relations, physio-structure, pschyo-nature. There are many advantages to such a simulation: subjects are readily available, they cost less than paying human subjects, the cycle of an animal's life is shorter than that of a human (shades of real time), it is easier to define the population from which the sample is taken, and if the model should "destruct", an experimental failure, it causes no damage to the human system except for the selfesteem of the experimenter. Wiener (1970) suggests that cybernetic principles have application in the behaviorial sciences, but must be used with caution.

Models that describe conflict have been suggested by Boulding (1963) and Schelling (1968). Nagel (1969) describes models of various legal processes and Fiedler (1967) postulates leadership models. Human relations in business management is described by Davis (1967). DeGreen (op. cit.) lists models in human factors engineering. Siegel and Wolf (1969) have produced computer simulation models of military establishments and crews. Simulations of society have been described by Raser (1969), and various models of processes have been described by Miller (1964) and Uttal (1969). Shubik (1964) applies game theory to social situations. Experimental results in human factors engineering can be applied to model design, for instance, the significance of the knowledge of results. E. Wiener (1969), has implications in the design of a feedback component. A mathematical approach is inherent in the design of most models. Parsons and Shils (1962) describe human interactions in terms of a monadic unit and a dyadic unit (which suggests a finite state automaton, though neither automaton nor simulation is mentioned). Garner (1970) gives illustrations of patterns of "cellular automata."

Behaviorial scientists have been quick to use the computer for statistical analysis. Others have seen the possibility of computer simulation of personality. Tomkins and Messick (1963) reported the results of a conference at Princeton on the theme of the simulation of personality. Loehlin (1968) describes in greater detail the Princeton models and factors that should be considered in computer simulation of personality. A recent review of personality models made by Emshoff and Sisson (1970) concludes that "such models are rare and hypotheses upon which they can be built are practically nonexistent."

The examples cited above indicate some of the applications of systems analysis to this area, and the variety of models which have been suggested in the behaviorial sciences. However, a cybernetic approach to the solution of social problems in the dynamic sense that physical scientists have applied such principles is apparently new. Extensive literature search has failed to uncover any examples of a cybernetic approach to human relations. Therefore, we conclude that the development of plausible mathematical models and computer simulation as tools in a systems analysis of human relations is a promising area for new research. This suggests the new subject of Sociocybernetics, the application of cybernetic principles to a systems analysis of social structures.

APPENDIX B

THE DISCRETE SYSTEM

APPENDIX B-1 DESIGN OF GENESIS MODEL-ONE

The following postulates were used in the development of the GENESIS MODEL-ONE.

POSTULATE I: The interaction of human beings is a dynamic system.

A. A DYNAMIC SYSTEM, by definition, consists of the following:

Components; C

Connection Matrix; M

Initial Conditions; α

$\left.\begin{array}{l}\text{Inputs; } I \\ \text{Output; } \theta\end{array}\right\}$ over time

B. The System may be thought of as a black box, in which the components are in an initial condition, receive inputs and give outputs and in which some portion of the output may be input into other components within the system. The system consists of what is in the black box.

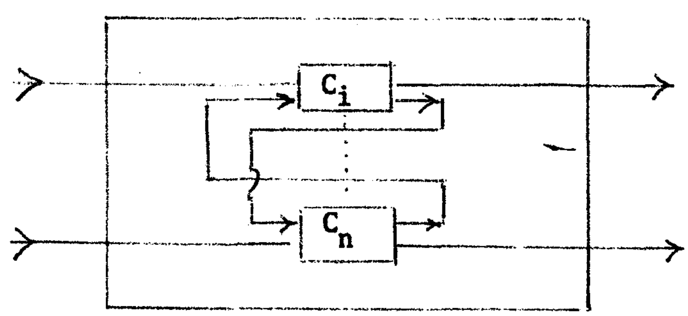

Figure 6 A dynamic system

C. The Behavior of the system is expressed in terms of its output as a function of its other characteristics and time.

$$\theta = f(C, M, \alpha, I, t)$$

The next postulate develops the concept of the COMPONENT DESIGN:

POSTULATE II: Each component is a finite state automaton.

The characteristics of a finite state automaton are:

It has a finite set i, of internal states in which it can exist; and a finite set e, of external environments which it can perceive as inputs and produce as outputs.

The dynamic behavior of a finite state automaton is determined by two functions, one of which specifies the next internal state, the other of which specifies the external environment, each as functions of the present internal state and environment. In symbols:

$$i_{n+1} = f(e_n, i_n)$$

$$e_{n+1} = g(e_n, i_n)$$

The two equations apply pair-wise, not cyclicly.

THE GENESIS MODEL-ONE has the smallest meaningful number of internal and external states, two each. A person is described by two 2-by-2 matrices, one for OUTPUT and the other for NEXT STATE. Within each cell of the matrix, a plus 1 or minus 1 indicates the nature of response in a given environment and a given internal state. For instance, a sample individual design is shown in Table 14.

Table 14

FINITE STATE AUTOMATON MODEL OF A PERSON

ENVIRONMENT

INPUT / STATE	GOOD	POOR
HAPPY	1	1
SAD	1	-1

OUTPUT

INPUT / STATE	GOOD	POOR
HAPPY	1	-1
SAD	-1	-1

NEW STATE

If the person in Table 14 is in a "plus" state and a "negative" environment, his output will be "+" and his next state "-"; or if in negative state and a negative environment, his next output will be "-" and his next state will be "-".

In GENESIS MODEL-ONE we have said that the internal states may be "happy" or "sad" and that the environment may be either "good" or "poor". In the feasibility experiment, one could just as well have described internal states as aggressive, non-aggressive, etc.

Given this design there are a possible 256 different combinations or model designs:

$$(2 \times 2)^{(2 \times 2)} = 4^4 = 256$$

The next element in a dynamic system is the CONNECTION MATRIX.

POSTULATE III: The interconnections between persons can by described by a nxn connection matrix connecting the n components C_j. Table 15 is an illustration of such a matrix, M.

Table 15

CONNECTION MATRIX M FOR N COMPONENTS

INPUT / OUTPUT	C_1	----------------	C_j	---------------- C_n
C_1				
⋮				
C_i			M_{ij}	
⋮				
C_n				

Where M_{ij} the amount of output from component C_i which is input into component C_j.

For illustrative purposes, the GENESIS MODEL-ONE has the smallest number of persons in interrelations, that is two. We also make the following assumptions:

The man's total output is perceived by the woman as her total input and the woman's total output is perceived by the man as his total input. While self feedback is a part of human encounters and can be designed into other models, in order to facilitate this first model design there is no self feedback.

Table 16

GENESIS MODEL ONE CONNECTION MATRIX

OUTPUT \ INPUT	MAN	WOMAN
MAN	0	1
WOMAN	1	0

This leads to a computation of the number of systems possible for the two person, two state automaton: Since there can be 256 designs for the man, a like number is possible for the woman, and hence:

(Man designs) x (woman designs) = (256) x (256) = 65,536 different systems.

The next element is INPUT. We assume in this first simulation that the two persons move into the proverbial black box, in any one of several possible initial conditions. There are no inputs during the simulation. Future models could incorporate stochastic inputs.

The final element in the output is the nature of the INITIAL CONDITIONS. There are sixteen initial conditions which range from all negative states and environments to all positive. A systematic way of enumerating these, binary counting, is in Table 17.

Table 17

SIXTEEN INITIAL CONDITIONS

MAN		WOMAN	
STATE	ENVIRONMENT	STATE	ENVIRONMENT
-1	-1	-1	-1
-1	-1	-1	+1
-1	-1	+1	-1
-1	-1	+1	+1
⋮	⋮	⋮	⋮
+1	+1	+1	+1

GENESIS ONE thus simulates human relations by determining the output of the system as a function of its parameters:

$$\theta = f(C, M, \alpha, t) \quad \text{with no Inputs.}$$

An example of an actual simulation is the computer simulation output of one system, Appendix B-7.

APPENDIX B-2

COMPUTATION OF VARIOUS OUTPUTS PRODUCED BY THE GENESIS SYSTEM

1. STEADY STATE is defined as that condition in which the system output at time t+1 is exactly the same as at time t. With the same logic as developed in Appendix B-1 for determination of the initial conditions, there are 16 different possible steady state results.

2. A CYCLE is a system output which returns to the starting state in n time steps, and thus starts to repeat itself. There are many different possible combinations, but the length n of the cycle varies from 2 to 16 states in length.

   In a statistical analysis of each system, we can determine the number of each kind of steady state; the number of different cycles of 2 to 16 states in length; the number of distinct kinds of 2 to 16 state cycles; the number of occurrences of each.

3. The ACCEPTABILITY or UNACCEPTABILITY of a given simulation is determined by an analysis of the man's state and of the woman's state, independent of the output of each. If each person is in a positive state more often than not, that simulation from a given initial condition is called ACCEPTABLE: otherwise it is UNACCEPTABLE.

4. STRIFE INDEX is the percentage of the minuses (it is analagous to a measure of the entropy of the system). Let N equal the number of negative elements in a total steady state (from 0 to 4) or be equal to the number of total negatives in a complete cycle of 2 to 16 states, and let C equal the number of states in the cycle, from 1 in a steady state to 16 in the largest possible cycle. Then the Strife Index SI is defined to be:

$$SI = \frac{1}{4} \sum (N_i/C_i)$$

Consider the Strife Index from a given initial condition:

If there is no strife in the system then the strife index = 0.00; at the other extreme:

Total Strife = 1.00

Acceptability and unacceptability and the strife index are examples of the sorts of measurements that might be computed. There are many conceivable measurements of the relative success of a given system, based on different sets of subjective values.

APPENDIX B-3

BINOMIAL NOMANCLATURE

With 65,520 possible systems, the identification of all possible combinations can be done by assigning sixteen different first names to the man's output and sixteen different last names to his Next State matrix, and similarly for the woman. Thus thirty two names can describe all possible 256 different men, and since the same number can describe in various combinations all different 256 women, 64 names can describe all combinations for 65,536 couples.

An example will be given using the man's output matrix. The four elements can each be plus or minus. Let the matrix elements be enumerated in the order row 1, column 1; row 1, column 2; row 2, column 1, row 2, columm 2. There are 2^4 = 16 possible combinations. All are listed in

Table 18. To each can be assigned a name. A suggestion is made in Table 18.

Table 18

BIONOMIAL NOMANCLATURE FOR MAN'S OUTPUT MATRIX

POSSIBLE OUTPUT	NAME
+ + + +	Albert
+ + + -	Bertram
+ + - +	Charles
+ + - -	David
+ - + +	Elbert
⋮	⋮
- - - -	Peter

In like manner a different set of names could be assigned to the next state matrix. Thus any one of the possible 256 designs of a man can be named by a combination of his two matrix names. Similarly all designs for the woman can be named.

APPENDIX B-4 STATISTICS DERIVED FROM SIMULATION

Two hundred and fifty different couples have been simulated. From the 4000 Initial conditions, there were 1138 acceptable simulations, a total of 28.4 percent. A summary of the results appears in Table 19.

Table 19

SUMMARY OF 250 SIMULATIONS FROM 4000 INITIAL CONDITIONS

STATISTIC	STEADY STATES	CYCLES
Total each type	2450	1550
Percent of total	61.3%	37.7%
Total each type acceptable	1016	122
Percent acceptable	41.5%	7.9%

Table 20, which is a computer output, is an example of the extensive summary that is computed at the end of each system simulation from sixteen initial conditions. System 1 in the system described in Experiment I-A in the body of the thesis.

APPENDIX B-5 THE MAGNITUDE OF A THREE STATE SIMULATION

A three state simulation as described in Experiment 1-C has 9 x 9 = 81 different initial conditions.

There are $(3 \times 3)^{(3 \times 3)} = 9^9 = 3.87 \times 10^8$ designs for one person.

Total number of systems = $9^9 \times 9^9 = 1.5 \times 10^{17}$

If the present population of the earth were all paried off, there would be about 1.5×10^9 couples, so this design would allow for 10^8 designs for each couple, a not inconsiderable variety.

SUMMARY OF SYSTEM 1

	TOTAL	ACCEPTABLE	UNACCEPTABLE
STEADY STATE	10	1	9
CYCLE COND.	6	0	6
SYSTEM TOTAL	16	1	15

STEADY STATE SUMMARY

STEADY STATE NUMBER	1*	2*	3	4	5*	6*	7	8	9	10	11	12	13	14
IN THIS SYSTEM	1	0	0	0	0	0	0	0	4	0	0	0	0	4

*=ACCEPTABLE STATE

CYCLE STATES SUMMARY

NUMBER CYCLE STATES	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NUMBER THIS SYSTEM	6	0	0	0	0	0	0	0	0	0	0	0	0	0
NUMBER OF DIFFERENT TYPES SAME CYCLE SIZE	1	0	0	0	0	0	0	0	0	0	0	0	0	0

SUMMARY OF DIFFERENT KINDS OF THE SAME STATE CYCLE THIS SYSTEM

	NUMBER	OF	GIVEN	STATES	PER	CYCLE									
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CYCLE TYPE 1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TYPE 2	0	0	0	0	0	0	0								
TYPE 3	0	0	0	0											
TYPE 4	0	0	0												
TYPE 5	0	0													
TYPE 6	0														
TYPE 7	0														
TYPE 8	0														

SYSTEM STRIFE INDEX =0.500
STRIFE INDEX ALL CYCLES=0.500
STRIFE INDEX ALL STEADY STATES=0.500

Table 20

A DISCRETE SYSTEM STATISTICAL SUMMARY

APPENDIX B-6 FLOW CHART OF COMPUTER SIMULATION

A simplified flow chart of this is shown in Figure 7.

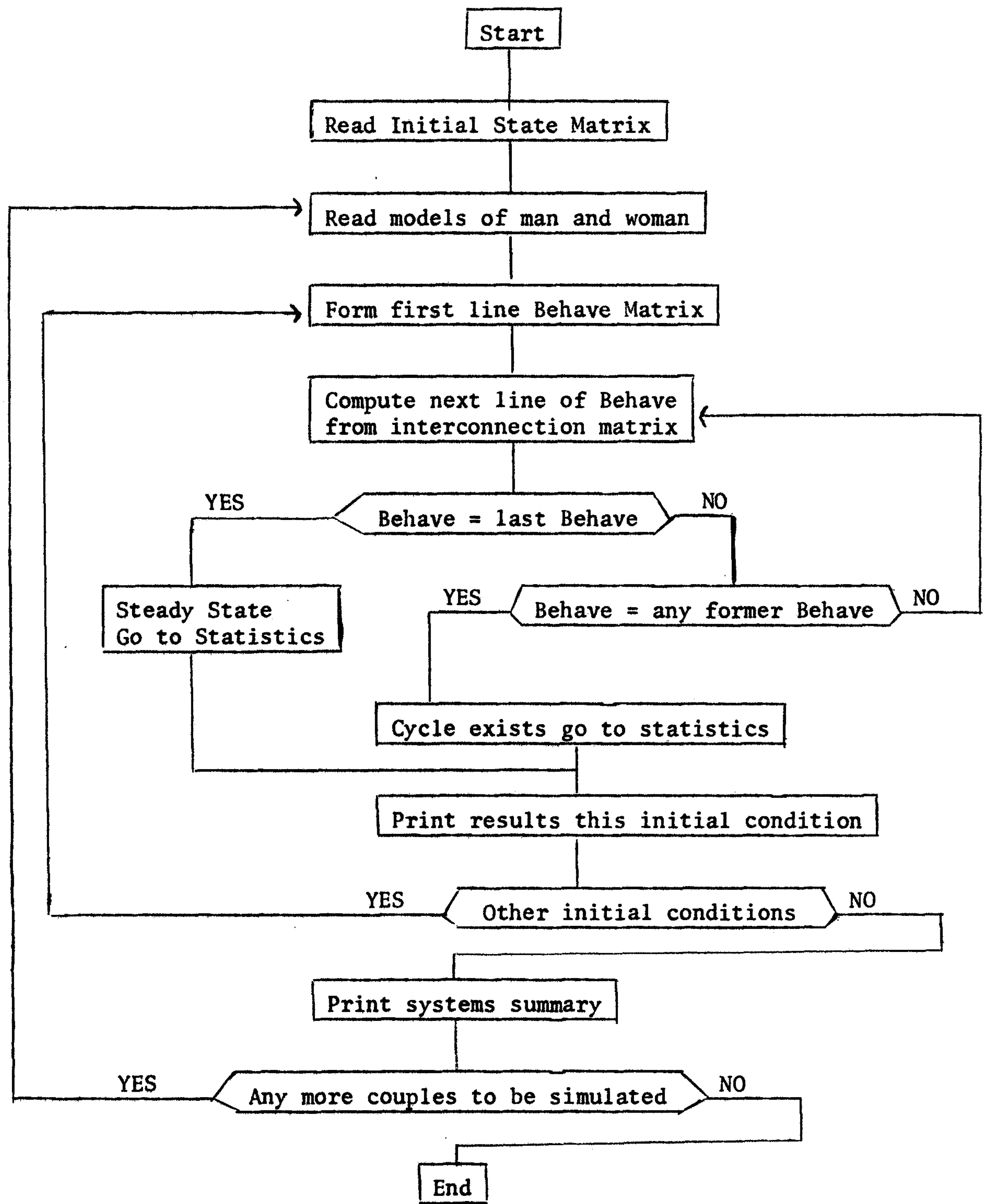

Figure 7

Simplified Flow Chart of Discrete Model Simulation

APPENDIX B-7 COMPUTER OUTPUT OF TWO STATE MODEL

Table 21

COMPUTER OUTPUT OF A TWO STATE MODEL

```
                 MODEL FOR THE MAN
          ENVIRONMENT
STATE   GOOD   POOR             GOOD   POOR
HAPPY     1      1      HAPPY     1     -1
  SAD     1     -1        SAD    -1     -1
          OUTPUT                 NEW STATE


                 MODEL FOR THE LADY
          ENVIRONMENT
STATE   GOOD   POOR             GOOD   POOR
HAPPY     1     -1      HAPPY     1      1
  SAD    -1     -1        SAD     1     -1
          OUTPUT                 NEW STATE



T H E       M A N      T H E       L A D Y
STATE       INPUT      STATE       INPUT

INITIAL CONDITION NUMBER :  1
        FIRST LINE IS THE INITIAL CONDITION
  1          1          1          1
  1          1          1          1
   THE LAST LINE IS A STEADY STATE
     THIS IS STEADY STATE CONDITION NUMBER  1
     ACCEPTABLE STEADY STATE
     STRIFE INDEX =0.000


INITIAL CONDITION NUMBER :  2
        FIRST LINE IS THE INITIAL CONDITION
  1          1          1         -1
  1         -1          1          1
 -1          1          1          1
 -1          1          1          1
   THE LAST LINE IS A STEADY STATE
     THIS IS STEADY STATE CONDITION NUMBER  9
     UNACCEPTABLE STEADY STATE
     STRIFE INDEX =0.250
```

Table 21 Continued

```
INITIAL CONDITION NUMBER :   3
          FIRST LINE IS THE INITIAL CONDITION
  1          1         -1          1
  1         -1          1          1
 -1          1          1          1
 -1          1          1          1
     THE LAST LINE IS A STEADY STATE
       THIS IS STEADY STATE CONDITION NUMBER   9
       UNACCEPTABLE STEADY STATE
       STRIFE INDEX =0.250

INITIAL CONDITION NUMBER :   4
          FIRST LINE IS THE INITIAL CONDITION
  1          1         -1         -1
  1         -1         -1          1
 -1         -1          1          1
 -1          1          1         -1
 -1         -1          1          1
     THE LAST  2 LINES FORM A CYCLE
     UNACCEPTABLE CYCLE

INITIAL CONDITION NUMBER :   5
          FIRST LINE IS THE INITIAL CONDITION
  1         -1          1          1
 -1          1          1          1
 -1          1          1          1
     THE LAST LINE IS A STEADY STATE
       THIS IS STEADY STATE CONDITION NUMBER   9
       UNACCEPTABLE STEADY STATE
       STRIFE INDEX =0.250

INITIAL CONDITION NUMBER :   6
          FIRST LINE IS THE INITIAL CONDITION
  1         -1          1         -1
 -1         -1          1          1
 -1          1          1         -1
 -1         -1          1          1
     THE LAST  2 LINES FORM A CYCLE
     UNACCEPTABLE CYCLE
       FIRST CYCLE CONDITION
       STRIFE INDEX =0.500
```

Table 21 Continued

```
INITIAL CONDITION NUMBER :  7
         FIRST LINE IS THE INITIAL CONDITION
 1        -1         -1          1
-1        -1          1          1
-1         1          1         -1
-1        -1          1          1
    THE LAST  2 LINES FORM A CYCLE
    UNACCEPTABLE CYCLE
      FIRST CYCLE CONDITION
      STRIFE INDEX =0.500


INITIAL CONDITION NUMBER :  8
         FIRST LINE IS THE INITIAL CONDITION
 1        -1         -1         -1
-1        -1         -1          1
-1        -1          1         -1
-1        -1          1         -1
    THE LAST LINE IS A STEADY STATE
      THIS IS STEADY STATE CONDITION NUMBER 14
      UNACCEPTABLE STEADY STATE
      STRIFE INDEX =0.750


INITIAL CONDITION NUMBER :  9
         FIRST LINE IS THE INITIAL CONDITION
-1         1          1          1
-1         1          1          1


    THE LAST LINE IS A STEADY STATE
      THIS IS STEADY STATE CONDITION NUMBER  9
      UNACCEPTABLE STEADY STATE
      STRIFE INDEX =0.250


INITIAL CONDITION NUMBER : 10
         FIRST LINE IS THE INITIAL CONDITION
-1         1          1         -1
-1        -1          1          1
-1         1          1         -1
    THE LAST  2 LINES FORM A CYCLE
    UNACCEPTABLE CYCLE
      FIRST CYCLE CONDITION
      STRIFE INDEX =0.500
```

Table 21 Continued

```
INITIAL CONDITION NUMBER : 11
         FIRST LINE IS THE INITIAL CONDITION
 -1         1         -1         1
 -1        -1          1         1
 -1         1          1        -1
 -1        -1          1         1
    THE LAST  2 LINES FORM A CYCLE
    UNACCEPTABLE CYCLE
      FIRST CYCLE CONDITION
      STRIFE INDEX =0.500


INITIAL CONDITION NUMBER : 12
         FIRST LINE IS THE INITIAL CONDITION
 -1         1         -1        -1
 -1        -1         -1         1
 -1        -1          1        -1
 -1        -1          1        -1
    THE LAST LINE IS A STEADY STATE
      THIS IS STEADY STATE CONDITION NUMBER 14
      UNACCEPTABLE STEADY STATE
      STRIFE INDEX =0.750


INITIAL CONDITION NUMBER : 13
         FIRST LINE IS THE INITIAL CONDITION
 -1        -1          1         1
 -1         1          1        -1
 -1        -1          1         1
    THE LAST  2 LINES FORM A CYCLE
    UNACCEPTABLE CYCLE
      FIRST CYCLE CONDITION
      STRIFE INDEX =0.500


INITIAL CONDITION NUMBER : 14
         FIRST LINE IS THE INITIAL CONDITION
 -1        -1          1        -1
```

Table 21 Continued

```
-1          -1          1          -1
   THE LAST LINE IS A STEADY STATE
     THIS IS STEADY STATE CONDITION NUMBER 14
     UNACCEPTABLE STEADY STATE
     STRIFE INDEX =0.750


INITIAL CONDITION NUMBER : 15
        FIRST LINE IS THE INITIAL CONDITION
-1          -1          -1          1
-1          -1          1          -1
-1          -1          1          -1
   THE LAST LINE IS A STEADY STATE
     THIS IS STEADY STATE CONDITION NUMBER 14
     UNACCEPTABLE STEADY STATE
     STRIFE INDEX =0.750


INITIAL CONDITION NUMBER : 16
        FIRST LINE IS THE INITIAL CONDITION
-1          -1          -1          -1
-1          -1          -1          -1
   THE LAST LINE IS A STEADY STATE
     THIS IS STEADY STATE CONDITION NUMBER 16
     UNACCEPTABLE STEADY STATE
     STRIFE INDEX =1.000
```

A summary table produced by this simulation is Table 20, page 46.

APPENDIX C

THE CONTINUOUS SYSTEM

APPENDIX C-1 GENERAL RESEARCH PLAN FOR THE CONTINUOUS SYSTEM

I. Set up the model.

  A. Lay down postulates.

  B. Construct continuous model.

II. Analyze the model.

  A. Local behavior.

    1. Determine critical points.

    2. Classify critical points (solve algebraic eigenvalue problem for Jacobian at critical point).

      a. Identify dominant linear terms.

      b. Find eigenvalues of resulting matrix.

      c. Find eigenvectors of resulting matrix.

  B. Global Behavior.

    1. Find critical orbits.

    2. Determine topology (especially connection) of the phase space.[7]

APPENDIX C-2 POSTULATES AND MATHEMATICAL EQUATIONS FOR THE CONTINUOUS MODEL

The model is a continuous state dynamic system with each component

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[7] Howard, B. E., "Nonlinear System Simulation", SIMULATION, October 1966, pp. 205-211, for a tutorial resumé of phase space analysis.

characterized by an internal state and an output. The following postulates are made about the GENESIS TWO Model:

POSTULATE I: The INTERNAL STATE

I-A: A person's mood doesn't change without a cause. This is the principle of "MOOD INERTIA".

I-B: The Internal State tends to change in the same sense as the input.

(i.e., Terms $a_{14}\theta_f$ and $a_{32}\theta_m$ in the model)

I-C: The Internal State tends to change in the opposite sense of the output:

(i.e., Terms $-a_{12}\theta_m$ and $-a_{34}\theta_f$ in the model)

POSTULATE II: The OUTPUT

II-A: The output tends to change in the same sense as the internal state.

(i.e., Terms $a_{21}S_m$ and $a_{43}S_f$ in the model)

NOTE: The input from the other person which is a component of the output is assumed to have first gone through the internal state, and thus is not included in the equation for output.

POSTULATE III: BOUNDEDNESS

III-A: All variables, both for internal state and output, are bounded. The boundedness is assured by the nonlinear terms such as $(1 - S_m^2)$ in the model.

THE DEVELOPMENT OF THE MATHEMATICAL EQUATIONS

In the discrete model, GENESIS ONE, we assumed that human behavior moved in discrete units or time. The continuous model makes the alternate assumption, that humans move continuously from one state condition to another.

The derivation of the continuous model from the basic postulates is illustrated by the local behavior of the man's internal state, S_m:

$$S_m(t + dt) = S_m(t) + dt(-a_{12}\theta_m + a_{14}\theta_f)(\cdots)$$

The increment added to the local state is proportional to time and the incremental forces specified by postulates I (the terms in parentheses). Therefore:

$$\frac{S_m(t + dt) - S_m(t)}{dt} = (-a_{12}\theta_m + a_{14}\theta_f)(\cdots)$$

$$\lim_{dt \to 0} \frac{S_m(t + dt) - S_m(t)}{dt} = \frac{dS_m}{dt} \quad \text{(The definition of the derivative.)}$$

$$S'_m = (-a_{12}\theta_m + a_{14}\theta_f)(\cdots)$$

By Postulate III we have bounded each variable, thus the final equation for man's internal state is:

$$S'_m = (-a_{12}\theta_m + a_{14}\theta_f)(1 - S_m^2)$$

and similarly for changes in the other state variables.

The continuous model consists of two persons, each of whom is described by two differential equations, one for internal state and one for output. Thus the system is described by the following set of four equations, each derived in the same fashion as in the case for S'_m.

$$S'_m = (-a_{12}\theta_m + a_{14}\theta_f)(1 - S_m^2)$$

$$\theta'_m = (a_{21}S_m)(1 - \theta_m^2)$$

$$S'_m = (a_{32}\theta_m - a_{34}\theta_f)(1 - S_f^2)$$

$$\theta'_f = (a_{43}S_f)(1 - \theta_f^2)$$

Where:

S_m is the Man's Internal State

θ_m is the Man's Output

S_f is the Woman's Internal State

θ_f is the Woman's Output.

' represents time derivative.

APPENDIX C-3 PHASE SPACE ANALYSIS

The phase space of a dynamic system $y' = f(y)$ is defined to be the space of the dependent variables. In the continuous model of human relations under discussion, it is the space of the variables S_m, θ_m, S_f and θ_f. To determine the qualitative behavior of the system under all circumstances, we conduct the following phase space analysis:

1. Find the critical points by setting $f(y) = 0$, and solve for y.

2. Take one critical point, say y_c, translate axes to y_c as origin by the linear transformation:

$$y = y_c + \zeta, \text{ etc.}$$

3. Expand the new $f(\zeta)$ about the origin, retain only linear terms, get $\mathring{\zeta} = A\zeta$ where A is a square matrix.

4. Find eigenvalues and eigenvectors of Matrix A. Refer system to new coordinate axes in which each eigenvector is one of the new axes.

5. Behavior of solution to equations along **each** new eigenvector axis is proportional to $e^{\lambda t}$, where λ is the eigenvalue.

λ is real < 0 critical points λ is real > 0

solution stable   solution unstable

Figure 8 Local behavior with real eigenvalues

If λ is a complex number there is oscillation about the critical point. A stable oscillation heads into the critical point, an unstable oscillation spirals away from the critical point. This is determined by the sign of the real part of the complex λ. The imaginary part of the complex λ is the frequency of the oscillation.

real part $\lambda > 0$ real part $\lambda < 0$

Figure 9 Local behavior with imaginary eigenvalues

APPENDIX C-4 DETERMINATION OF CRITICAL POINTS

Critical points are found by setting the four differential equations of this system to zero. (Since they are already of first order, they do not have to be converted.) The critical points are:

$$S_m = \pm 1; \quad \theta_m = \pm 1; \quad S_f = \pm 1; \quad \theta_f = \pm 1,$$

(the sixteen vertices of a tesseract, or 4 dimensional cube.)

and

$$(S_m, \ \theta_m, \ S_f, \ \theta_f) = (0, \ 0, \ 0, \ 0).$$

The complete phase space analysis of the system is made by performing a local analysis of the system behavior at each of the vertices and the origin, or a total of 17 critical points, and determining separatrices by integrating the differential equations starting along each of the special (eigenvector) local directions.

APPENDIX C-5 CRITICAL POINT ANALYSIS OF THE VERTICES OF THE TESSERACT

An example of the procedure for calculation of the eigenvectors at the 16 critical points (+1, +1, +1, +1) is as follows:

AT CRITICAL POINT (-1, -1, -1, -1):

Let: $\zeta_i = (-1 + \zeta_i)$; $\theta_i = (-1 + \eta_i)$

Then: $\overset{\circ}{\zeta}_m = [-a_{12}(-1 + \eta_m) + a_{14}(-1 + \eta_f]\zeta_m(2 - \zeta_m)$

$$\overset{\circ}{\theta}_m = [a_{21}(- + \zeta_m)]\eta_m(2 - \theta_m)$$

$$\overset{\circ}{\zeta}_f = [a_{32}(-1 + \eta_m) - a_{34}(-1 + \eta_f)]\zeta_f(2 - \overset{\circ}{\zeta}_f)$$

$$\overset{\circ}{\theta}_f = [a_{43}(-1 + \zeta_f)]\eta_f(2 - \theta_f)$$

The equations are expanded as follows:

$$\begin{pmatrix} \overset{\circ}{\zeta}_m \\ \overset{\circ}{\theta}_m \\ \overset{\circ}{\zeta}_f \\ \overset{\circ}{\theta}_f \end{pmatrix} = 2 \begin{pmatrix} (a_{12} - a_{14}) & 0 & 0 & 0 \\ 0 & -a_{21} & 0 & 0 \\ 0 & 0 & (a_{34} - a_{32}) & 0 \\ 0 & 0 & 0 & -a_{43} \end{pmatrix} \begin{pmatrix} \zeta_m \\ \theta_m \\ \zeta_f \\ \theta_f \end{pmatrix} + \text{higher order terms}$$

The above coefficient matrix is the Jacobian of the expressions for the derivatives at the critical point in question. The four terms will determine the nature of each of the four eigenvectors at this vertex (and it turns out that each of the sixteen vertices has a diagonal Jacobian). From the diagonal nature of the Jacobian we see that the eigenvectors are the four edges of the tesseract emanating from the vertex. If the eigenvalue (diagonal term) corresponding to a given eigenvector is positive the corresponding solution is unstable; if it is negative it is stable and the solution trajectcry leads into the vertex at the critical point:

+ is unstable, solution goes away from critical point

- is stable, solution goes into critical point.

An analysis similar to the above must be made for each of the 15 remaining vertices, i.e., just put appropriate ± values into the Jacobian:

$$\text{Jacobian}\ \frac{\partial(S_m',\theta_m',S_f',\theta_f')}{\partial(S_m,\theta_m,S_f,\theta_f)} = \begin{pmatrix} -2S_m(-a_{12}\theta_m+a_{14}\theta_f), & -a_{12}(1-S_m^2), & 0 & , a_{14}(1-S_m^2) \\ a_{21}(1-S_m^2) & , -2a_{21}S_m\theta_m , & 0 & 0 \\ 0 & , a_{32}(1-S_f^2), & -2S_f(a_{32}\theta_m-a_{34}\theta_f), & -a_{34}(1-S_f^2) \\ 0 & , \quad 0 \quad , & a_{43}(1-\theta_f^2) & , -2a_{43}S_f\theta_f \end{pmatrix}$$

The results are summarized in Table 22.

Table 22

SUMMARY OF CRITICAL POINT ANALYSIS AT VERTICES

Number	Critical Point	S_m	θ_m	S_f	θ_f
1	(-1,-1,-1,-1)	$a_{12} - a_{14}$	$-a_{21}$	$a_{34} - a_{32}$	$-a_{43}$
2	(-1,-1,-1,+1)	$a_{12} + a_{14}$	$-a_{21}$	$-(a_{32} + a_{34})$	a_{43}
3	(-1,-1,+1,-1)	$a_{12} - a_{14}$	$-a_{21}$	$a_{32} - a_{34}$	a_{43}
4	(-1,-1,+1,+1)	$a_{12} + a_{14}$	$-a_{21}$	$a_{32} + a_{34}$	$-a_{43}$
5	(-1,+1,-1,-1)	$-(a_{12} + a_{14})$	a_{21}	$a_{32} + a_{34}$	$-a_{43}$
6	(-1,+1,-1,+1)	$a_{14} - a_{12}$	a_{21}	$a_{32} - a_{34}$	a_{43}
7	(-1,+1,+1,-1)	$-(a_{12} + a_{14})$	a_{21}	$-(a_{32} + a_{34})$	a_{43}
8	(+1,+1,+1,+1)	$a_{14} - a_{12}$	a_{21}	$a_{34} - a_{32}$	$-a_{43}$
9	(+1,-1,-1,-1)	$a_{14} - a_{12}$	a_{21}	$a_{34} - a_{32}$	$-a_{43}$
10	(+1,-1,-1,+1)	$-(a_{12} + a_{14})$	a_{21}	$-(a_{32} + a_{34})$	a_{43}
11	(+1,-1,+1,-1)	$a_{14} - a_{12}$	a_{21}	$a_{32} - a_{34}$	a_{43}
12	(+1,-1,+1,+1)	$-(a_{12} + a_{14})$	a_{21}	$(a_{32} + a_{34})$	$-a_{43}$
13	(+1,+1,-1,-1)	$a_{12} + a_{14}$	$-a_{21}$	$a_{32} + a_{34}$	$-a_{43}$
14	(+1,+1,-1,+1)	$a_{12} - a_{14}$	$-a_{21}$	$a_{32} - a_{34}$	a_{43}
15	(+1,+1,+1,-1)	$a_{12} + a_{14}$	$-a_{21}$	$-(a_{32} + a_{34})$	a_{43}
16	(+1,+1,+1,+1)	$a_{12} - a_{14}$	$-a_{21}$	$a_{34} - a_{32}$	$-a_{43}$

As we show later, the relative values of the a_{ij} elements will determine for a given system the qualitative nature of the particular eigenvector, stable or unstable.

APPENDIX C-6 CRITICAL ANALYSIS AT THE ORIGIN: (0,0,0,0)

The coefficent matrix A of linear terms governing the behavior of the system in the neighborhood of the origin is:

$$A = \begin{vmatrix} 0 & -a_{12} & 0 & a_{14} \\ a_{21} & 0 & 0 & 0 \\ 0 & a_{32} & 0 & -a_{34} \\ 0 & 0 & a_{43} & 0 \end{vmatrix}$$

The characteristic equation of A, $\det(A - \lambda I) = 0$, is:

$$\lambda^4 + (a_{12}a_{21} + a_{34}a_{43})\lambda^2 + a_{21}a_{43}(a_{12}a_{34} - a_{14}a_{32}) = 0.$$

The upper left and lower right 2 x 2 minors of A characterize the individual component behavior. That is,

> if $a_{14} = a_{32} = 0$, then there is no interaction, and each person is isolated and self-contained.

Let $a_{12}a_{21} = W_m^2$ where W_m equals the natural frequency of oscillation of the male.

$a_{34}a_{43} = W_f^2$ where W_f equals the natural frequency of oscillation of the woman.

$a_{14}a_{32}a_{21}a_{43} = W_s^4$ where W_s is the natural frequency of the coupled system with no internal feedback ($a_{12} = a_{34} = 0$)

Then the solutions of the characteristic equation for the eigenvalues, λ, can be written as:

$$2\lambda^2 = -(W_m^2 + W_f^2) \pm \sqrt{(W_m^2 - W_f^2)^2 + 4W_s^4}$$

Now since all a_{ij} are ≥ 0, the 3 W's are also ≥ 0 and hence the discriminant

$$(W_m^2 - W_f^2)^2 + 4W_s^4 \geq 0;$$

and is equal to 0 if and only if $W_m = W_f$ and $W_s = 0$. The latter case ($W_s = 0$) is an uncoupled system, each person being completely isolated from the other and this type system will not be considered further in this model.

With the discriminant > 0, there are two qualitatively distinct situations for the eigenvalues"

$$\text{discriminant} > \text{or} < (W_m^2 + W_f^2)^2.$$

This reduces to the two situations:

$$a_{14}a_{32} > \text{or} < a_{12}a_{34}.$$

Since a_{14} and a_{32} are the interacting terms, while a_{12} and a_{34} are the self-feedback terms, the two cases correspond to a strongly coupled and weakly coupled system, respectively.

When $a_{14}a_{32} > a_{12}a_{34}$ we have a stronger coupling with lesser self-feedback.

When $a_{14}a_{32} < a_{12}a_{34}$ we have a weaker interaction, or coupling, with greater self-feedback.

The first case produces a conjugate pair of pure imaginary eigenvalues (an undamped oscillation of that frequency in the neighborhood of the origin), a positive real eigenvalue and corresponding unstable direction (eigenvector) and a negative real eigenvalue and corresponding stable direction at the origin.

The second case produces two conjugate pairs of pure imaginary eigenvalues, each corresponding to an undamped oscillation in the neighborhood of the origin. The eigenvectors determine the real planes of the oscillations, which in general are different. Each of the above situations is illustrated by a case example.

APPENDIX C-7 CLASSIFICATION OF QUALITATIVELY DISTINCT CASES

From the table in Appendix C-4, we see that the local behavior at the vertices is governed by the relative magnitudes of a_{12} vs. a_{14}, and a_{32} vs. a_{34}. From the analysis in Appendix C-6, we see that the local behavior at the origin is governed by the relative magnitude of $a_{14}a_{32}$ vs. $a_{12}a_{34}$. Thus there are six qualitatively different cases that can be subjected to simulation. These are:

CASE 1: $a_{12} > a_{14}$ $a_{32} > a_{34}$ $a_{14}a_{32} > a_{12}a_{34}$

A strongly coupled system, each most effected by man's output.

CASE 2: $a_{12} > a_{14}$ $a_{32} > a_{34}$ $a_{14}a_{32} < a_{12}a_{34}$

A weakly coupled system, each most affected by man's output.

CASE 3: $a_{12} > a_{14}$ $a_{32} < a_{34}$ $a_{14}a_{32} < a_{12}a_{34}$

A weakly coupled system, each most affected by own output.

CASE 4: $a_{12} < a_{14}$ $a_{32} > a_{34}$ $a_{14}a_{32} > a_{12}a_{34}$

A strongly coupled system, each most affected by other's output.

CASE 5: $a_{12} < a_{14}$ $a_{32} < a_{34}$ $a_{14}a_{32} > a_{12}a_{34}$

A strongly coupled system, each most affected by woman's output.

CASE 6: $a_{12} < a_{14}$ $a_{32} < a_{34}$ $a_{14}a_{32} < a_{12}a_{34}$

A weakly coupled system, each most affected by woman's output.

A second descriptive classification is:

1. Strongly coupled $a_{14}a_{32} > a_{12}a_{34}$
   a. Male introvert, female extrovert; $a_{12} > a_{14}$, $a_{32} > a_{34}$
   b. Male extrovert, female introvert; $a_{12} < a_{14}$, $a_{32} < a_{34}$
   c. Male extrovert, female extrovert; $a_{12} < a_{14}$, $a_{32} > a_{34}$
2. Weakly coupled $a_{12}a_{34} > a_{14}a_{32}$
   a. Male extrovert, female introvert; $a_{12} > a_{14}$, $a_{32} > a_{34}$
   b. Male introvert, female extrovert; $a_{14} > a_{12}$, $a_{34} > a_{32}$
   c. Male introvert, female introvert; $a_{12} > a_{14}$, $a_{34} > a_{32}$

Since we have three elements taken two at a time, we could assume that there should be eight different cases. There are, but the remaining two are impossible from both a mathematical concept and from a human relations viewpoint:

$$a_{12} > a_{14}, \quad a_{32} < a_{34}, \quad a_{14}a_{32} > a_{21}a_{34} \quad \text{is impossible;}$$

to have a strongly coupled system when each person is more effected by his own output, cannot happen.

$$a_{12} < a_{14}, \quad a_{32} > a_{34}, \quad a_{14}a_{32} < a_{21}a_{34} \quad \text{is impossible;}$$

to have a weakly coupled system when each person is more strongly effected by the other person's output, cannot happen; for this would imply a strongly coupled system. Mathematically, we can easily show that for $a_{ij} > 0$,

$$a_{12} > a_{14} \text{ and } a_{34} > a_{32} \rightarrow a_{12}a_{34} > a_{14}a_{32} \text{ and}$$

$$a_{14} > a_{12} \text{ and } a_{32} > a_{34} \rightarrow a_{14}a_{32} > a_{12}a_{34};$$

$$(a_{12} > a_{14}) \wedge (a_{34} > a_{32}) \rightarrow (a_{12} = a_{14} + b) \wedge (a_{32} = a_{32} + c) \rightarrow a_{12}a_{32} = a_{14}a_{32} + ba_{32} + ca_{14} + bc \rightarrow a_{12}a_{32} > a_{14}a_{32}.$$

APPENDIX C-8 CONSTRUCTION OF TYPICAL CASES

We now have the problem of simulating typical cases of each of the six types. It will be convenient to choose values of the a_{ij} such that the eigenvalues will be simple numbers to facilitate local hand checks. This is a Diophantine problem that can be solved with the help of Pythagorean numbers.

We have (page   ) expressed the characteristic equation in terms of the a_{ij} elements and then in terms of W_m, W_f, W_s, thus:

$$2\lambda^2 = [-(W_m^2 + W_f^2) \pm \sqrt{(W_m^2 - W_f^2)^2 + (2W_s^2)^2}\ ]$$

where

$$W_m^2 = a_{12}a_{21}$$

$$W_f^2 = a_{34}a_{43}$$

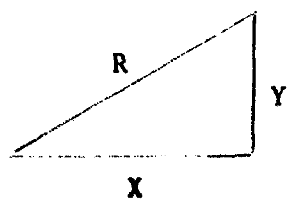
$$W_f^4 = a_{14}a_{32}a_{21}a_{43}$$

If the sum of the radical terms can be made equal to perfect square, the computations for λ are greatly simplified. This can be done by the use of a set of Pythagorean Numbers.

Table 23

PYTHAGOREAN NUMBERS

$m > n$ m	n	X $m^2 - n^2$	Y $2mn$	R $m^2 + n^2$
2	1	3	4	5
3	2	5	12	13
4	1	15	8	17
4	3	7	24	25



The values for X and Y in Table 23 represent the legs of a right triangle and R is the hypotenuse as illustrated in the sketch.

Let 2 W_s^2 = equal an even number (usually Y)

$(W_m^2 - W_f^2)$ may be either odd or even X or Y.

After values are thus determined, one may then determine combinations of integer a_{ij}'s that will satisfy both the W terms and the relative relationships for the case under analysis.

APPENDIX C-9 MATHEMATICAL CALCULATIONS FOR ANALYSIS OF AN ACTUAL CASE

CASE 3, APPENDIX C-7: $a_{12} > a_{14}$, $a_{32} < a_{34}$, $a_{14}a_{32} < a_{12}a_{34}$

values for all a_{ij}'s:

$a_{12} = 2$; $a_{14} = 1$; $a_{21} = 1$; $a_{32} = 2$; $a_{34} = 3$; and $a_{43} = 1$

Then

$$W_m^2 = a_{12}a_{21} = 2 \times 1 = 2$$

$$W_f^2 = a_{34}a_{43} = 3 \times 1 = 3$$

$$W_s^4 = a_{14}a_{32}a_{21}a_{43} = 2$$

$$2\lambda^2 = -(W_m^2 + W_f^2) \pm \sqrt{(W_m^2 - W_f^2)^2 + (2W_s^2)^2}$$

$$2\lambda^2 = -5 \pm \sqrt{(2 \times 3)^2 + 4 \times 2} = +5 \pm \sqrt{9} = -5 \pm 3$$

$$\lambda = \pm 2i, \pm 1i$$

The linear coefficient Matrix A is: $\begin{pmatrix} 0 & -2 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 2 & 0 & -3 \\ 0 & 0 & 1 & 0 \end{pmatrix}$

The eigenvector V is a nontrival solution of $(A - \lambda I)V = 0$. For the eigenvalue $\lambda = -i$, we have the equations

$$\begin{pmatrix} i & -2 & 0 & 1 \\ 1 & +i & 0 & 0 \\ 0 & 2 & i & -3 \\ 0 & 0 & 1 & i \end{pmatrix} \begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

Solution: $v_1 = -i$; $v_2 = +1$; $v_3 = -i$; $v_4 = +1$.

$$\text{Eigenvector} = \begin{pmatrix} -i \\ 1 \\ -i \\ 1 \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 1 \end{pmatrix} + i \begin{pmatrix} 1 \\ 0 \\ 1 \\ 0 \end{pmatrix}$$

The real and imaginary parts of the eigenvectors, taken as two real vectors, span **the real plane of this oscillation** in phase space. For starting point, choose a value in this plane. For instance,

Let $S_m = 0.1$

$\theta_m = 0.0$

$S_f = 0.1$

$\theta_f = 0.0$

Using the other conjugate pair of eigenvalues: $\lambda = \pm 2i$, use $-2i$ as the eigenvalue and obtain the corresponding

$$\text{eigenvector} = \begin{pmatrix} i \\ +1/2 \\ -2i \\ 1 \end{pmatrix} = \begin{pmatrix} 0 \\ -1/2 \\ 0 \\ 1 \end{pmatrix} + i \begin{pmatrix} 1 \\ 0 \\ -2 \\ 0 \end{pmatrix} .$$

Starting point

$S_m = 0.1$

$\theta_m = 0.0$

$S_f = -0.2$

$\theta f = 0.0$

The starting points are selected at some small distance from the origin, in the appropriate direction.

APPENDIX C-10 COMPUTER SIMULATION STEP SIZE

PERIOD CALCULATIONS

For man $= \frac{2\pi}{W_m}$ where $W_m = \sqrt{a_{12}a_{21}}$;

for woman $= \frac{2\pi}{W_f}$ where $W_f = \sqrt{a_{34}a_{43}}$;

for coupled system $= \frac{2\pi}{W_s}$ where $W_s = \sqrt[4]{a_{14}a_{21}a_{32}a_{43}}$;

an example calculation is for the system described in C-9;

Frequency for man : $W_m = \sqrt{2 \cdot 1} = \sqrt{2} = 1.414.$

Frequency for woman: $W_f = \sqrt{3 \cdot 1} = \sqrt{3} = 1.732$

Frequency for coupled system: $W_s = \sqrt[4]{1 \cdot 1 \cdot 1 \cdot 2} = \sqrt[4]{2} = 1.19.$

COMPUTER SIMULATION STEP SIZE

Let W = frequency in each of the system, within the system, divide the largest frequency into 2π, then divide this result by 12 and for adequate discrete definition of continuous oscillation, with acceptable discretezation error, round off to convenient stepsize for computer simulation.

For man $W_m = 1.1414,$

for woman $W_f = 1.732$, and for

coupled system $W_s = 1.19.$

We also have two pairs of eigenvalues ± 2i; ± 1i. Largest value of seven values above is 2.

$$\frac{2\pi}{W_{max}\ (12)} = \frac{2\pi}{2\ (12)} = \frac{\pi}{12} = .252.$$

STEPSIZE = 0.25

Since largest cycle is 5.28. A run of 6.0 would adequately include all cycyles.

DELT = 0.25

TIM MAX = 6.00

APPENDIX C-11 LOCAL BEHAVIOR AT VERTICES

Using the Jacobian matrix developed in Appendix C-5 and for values for a_{ij}'s that define Case 3, Appendix C-7;

$$a_{12} = 2;\quad a_{14} = 1;\quad a_{21} = 1;\quad a_{32} = 2;\quad a_{34} = 3;\quad a_{43} = 1,$$

we develop Table 24.

Table 24

Eigenvalues along each edge at each vertex

NUMBER	CRITICAL POINT	S_m	θ_m	S_f	θ_f
1	-1,-1,-1,-1	+1	-1	+1	-1
2	-1,-1,-1,+1	+3	-1	+1	1
3	-1,-1,+1,-1	+1	-1	-1	1
4	-1,-1,+1,+1	+3	-1	+5	-1
5	-1,+1,-1,-1	-3	1	+5	-1
6	-1,+1,-1,+1	-1	1	-1	1
7	-1,+1,+1,-1	+1	1	-5	1
8	-1,+1,+1,+1	-1	1	+1	-1
9	+1,-1,-1,-1	-1	1	+1	-1
10	+1,-1,-1,+1	-3	1	-5	1
11	+1,-1,+1,-1	-1	1	-1	1
12	+1,-1,+1,+1	-3	1	+5	-1
13	+1,+1,-1,-1	+3	-1	+5	-1
14	+1,+1,-1,+1	+1	-1	-1	1
15	+1,+1,+1,-1	+3	-1	-5	1
16	+1,+1,+1,+1	+1	-1	+1	-1

If the eigenvalue is + the eigenvector edge is unstable at Critical Point.

If eigenvalue is - the eigenvector edge is stable at Critical Point.

APPENDIX C-12 COEFFICIENTS FOR EACH QUALITATIVELY DISTINCT CASE

CASE 1

$a_{12} > a_{14}$ $\qquad$ $a_{32} > a_{34}$ $\qquad$ $a_{14}a_{32} > a_{12}a_{34}$

CASE 2

$a_{12} > a_{14}$ $a_{32} > a_{34}$ $a_{14}a_{32} < a_{12}a_{34}$

CASE 3

$a_{12} > a_{14}$ $a_{32} < a_{34}$ $a_{14}a_{32} < a_{12}a_{34}$

CASE 4

$a_{12} < a_{14}$ $a_{32} > a_{34}$ $a_{14}a_{32} > a_{12}a_{34}$

CASE 5

$a_{12} < a_{14}$ $a_{32} < a_{34}$ $a_{14}a_{32} > a_{12}a_{34}$

CASE 6

$a_{12} < a_{14}$ $a_{32} < a_{34}$ $a_{14}a_{32} < a_{12}a_{34}$

Table 25

COEFFICIENTS FOR EACH QUALITATIVELY DISTINCT CASE

CASE	a_{12}	a_{14}	a_{21}	a_{32}	a_{34}	a_{43}
1	2	1	1	6	1	1
2	9	2	4	4	3	2
3	2	1	1	2	3	1
4	1	2	1	3	2	1
5	1	3	2	2	3	1
6	2	3	2	1	3	1

APPENDIX C-13 CLASSIFICATION OF EDGES OF TESSERACT

A scheme to determine global behavior along each edge of the tesseract:

1. Place all sixteen vertices, one each on a three by five card: ex. for vertex #11:

   #11 (+1, -1, +1, -1)

2. Call the binary terms from left to right a b c d: in the above case +1 -1 +1 -1

   a b c d

3. Connect the various vertices as follows: start with vertex #1; note the value at point "d"; go through the deck of sixteen cards until the card differing from #1 only in the value of "d" is found. The two cards will identify the behavior of the solution vector along the tesseract edge connecting these vertices. Make a little mark on the card that contains the vertex so this particular value on that card can not be used again. Now go to card one, value "c", again go through the deck, noting the first card that has an opposite sign in its "c" column that is opposite to card one "c" column, again this will be the vertex to which the θ_m vector will go, check this value off the 3 by 5 cards. Repeat for column "b", then column "a". This will give the four vertices into which vectors S_m, θ_m, S_f, θ_f will go.

4. Repeat using vertex 2, in each case compare the a, b, c or d on card 2 with other cards starting with one, when an opposite sign is found that has not already been used, that is the vertex toward which the edge goes. As soon as a case is found, check that particular element on the "found card".

5. To determine the direction of the relationship from one vertex to the next, the following scheme is used:

   a. Take the five cards which make up any one set at a given vertex, i.e. the vertex and the four vertices to which each edge goes.

   b. Compare vertex column "a" with next vertex for S_m column "a", if they are one "plus" and one "minus" then vector always goes toward the - vertex. If they are the same, either plus or minus, then one must look at the coefficient matrix that was developed from the Jacobian Matrix, Appendix C-5.

By considering the coefficient relationships it will be possible to determine if there is one relationship that will always be negative, if so the edge will always be oriented in that direction, if not, the edge may be oriented in either direction, the direction dependent upon the values of the a_{ij}'s.

The results of these computations are shown in Table 26.

Table 26

CLASSIFICATION OF EDGES OF TESSERACT

VERTEX		θ_f	S_f	θ_m	S_m
1	----	1 ↢ 2	1 •→ 3	1 ↢ 5	1 ←• 9
*2	---+	2 ↣ 1	2 ↢ 4	2 ↢ 6	2 ↣ 10
3	--+-	3 ↣ 4	3 ←• 1	3 ↢ 7	3 ←• 11
*4	--++	4 ↢ 3	4 ↣ 2	4 ↢ 8	4 ↣ 12
*5	-+--	5 ↢ 6	5 ↣ 7	5 ↣ 1	5 ↢ 13
6	-+-+	6 ↣ 5	6 ←• 8	6 ↣ 2	6 •→ 14
*7	-++-	7 ↣ 8	7 ↢ 5	7 ↣ 3	7 ↢ 15
8	-+++	8 ↢ 7	8 •→ 6	8 ↣ 4	8 •→ 16
9	+---	9 ↢ 10	9 •→ 11	9 ↣ 13	9 •→ 1
*10	+--+	10 ↣ 9	10 ↢ 12	10 ↣ 14	10 ↢ 2
11	+-+-	11 ↣ 12	11 ←• 9	11 ↣ 15	11 •→ 3
*12	+-++	12 ↢ 11	12 ↣ 10	12 ↣ 16	12 ↢ 4
*13	++--	13 ↢ 14	13 ↣ 15	13 ↢ 9	13 ↣ 5
14	++-+	14 ↣ 13	14 ←• 16	14 ↢ 10	14 ←• 6
*15	+++-	15 ↣ 16	15 ↢ 13	15 ↢ 11	15 ↣ 7
16	++++	16 ↢ 15	16 •→ 14	16 ↢ 12	16 ←• 8

Indicates that edge must go in this direction

This is what happens when value of parameter of larger index is larger; i.e. $a_{34} > a_{32}$ or $a_{14} > a_{12}$

Edge may go in either direction depending on values of a_{ij}'s. In this assumed $a_{32} < a_{34}$ as a standard.

*Indicates vertices that never change in vector direction, will always have two going away and two coming in: A saddle point.

The vertices may be classified as in Table 27.

Table 27

VERTICES CLASSIFIED ACCORDING TO EDGE VARIABILITY

EDGE ORIENTATION	SOMETIMES STABLE VERTEX	SOMETIMES UNSTABLE VERTEX	ALWAYS SADDLE VERTEX
Variable	1, 16	6, 11	3,8,9,14
No Variability	None	None	2,4,5,7 10,12,13,15

We now have enough information to determine the direction of the eigenvectors at any one of the 16 vertices of the tesseract. We have shown in Figure 10 a scheme that indicates which vertices are connected. In addition, we have indicated those eigenvectors which must always go in a certain direction regardless of the values of the a_{ij}'s. The unmarked vectors go in a conditional direction which is determined by the particular values of the a_{ij}'s. This scheme will provide for the complete analysis at each of the 16 vertices for all qualitatively different system.

APPENDIX C-14 TOPOLOGY OF PHASE SPACE

Topologically there are four distinct phase spaces in respect to the vertices shown in Table 28. These are:

I. Man is dominant, an extrovert, system weakly or strongly coupled,

II. Neither person dominant, system weakly coupled,

III. Each person most effected by other person, strongly coupled system,

IV. Woman is dominant, an extrovert, system strongly or weakly coupled.

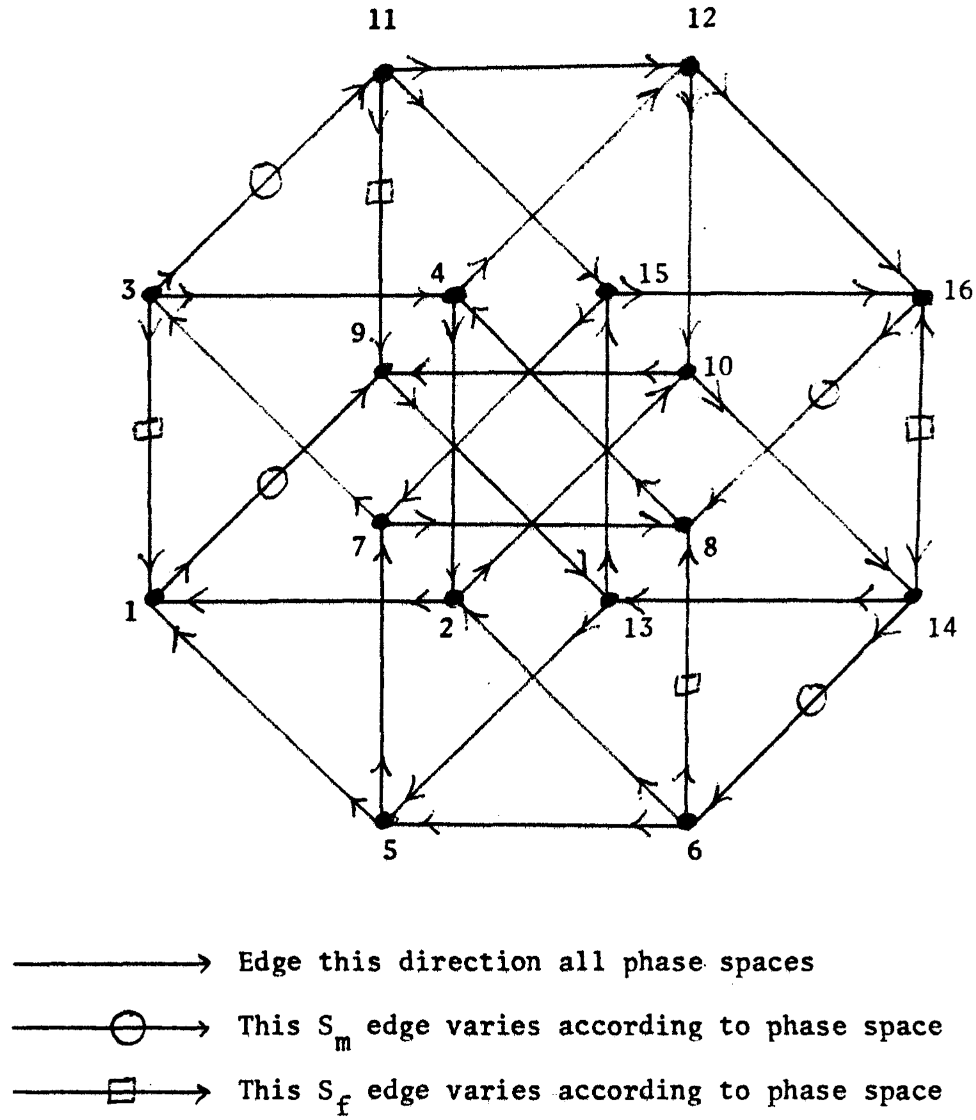
Table 28

TOPOLOGICALLY DISTINCT PHASE SPACES

PHASE SPACE	CASE FROM APPENDIX C-7	COEFFICIENT COMPARISONS		
		$a_{12} \sim a_{14}$	$a_{32} \sim a_{34}$	$a_{14}a_{32} \sim a_{12}a_{34}$
I	1	>	>	>
	2	>	>	<
II	3	>	<	<
III	4	<	>	>
IV	5	<	<	>
	6	<	<	<

In all cases but one (of the topologically distinct phase spaces), every vertex of the tesseract is a saddle point, with the number of unstable edges varving from 1 to 3. This means that there will be continual movement within the tesseract, as the dynamic relationship between the partners will never come to stable equilibrium.

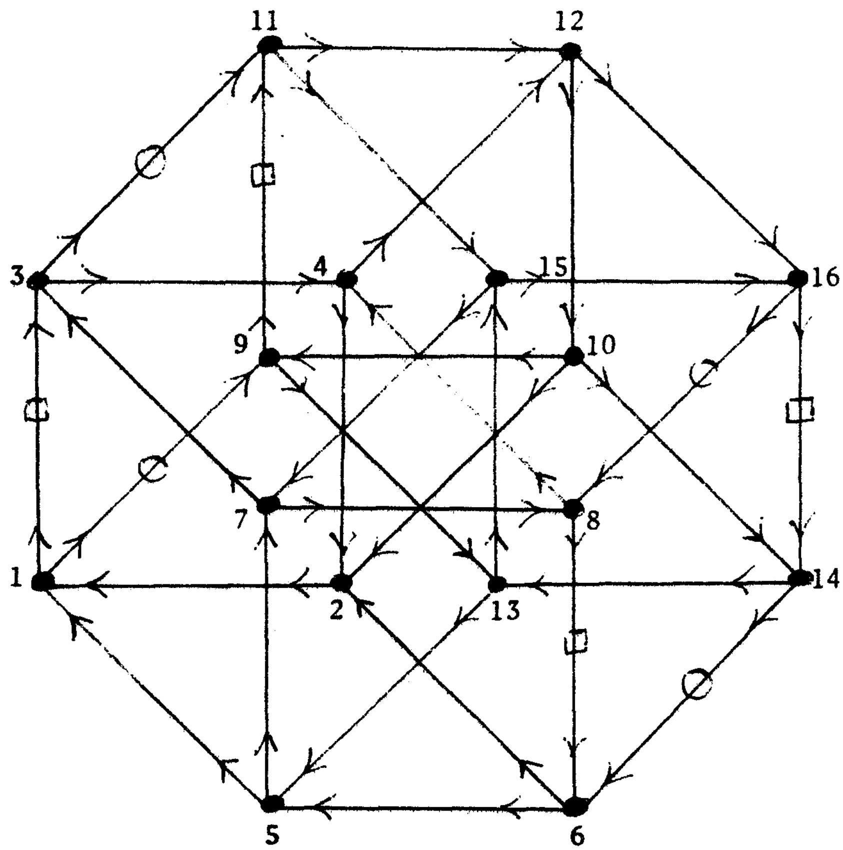
The one exception is that of the two "extroverts", or each person most strongly influenced by the other. In this case, vertices 6(-1,+1,-1,+1) and 11(+1,-1,+1,-1) are unstable. These are the situations when both partners are in phase; at vertex 6 both outputs are at positive saturation; at vertex 11, both internal states are at positive saturation and both outputs are at negative saturation; in neither case can the situation persist. Furthermore, vertices 1(-1,-1,-1,-1) and 16(+1,+1,+1,+1) are points of stable equilibrium; if either point is approached, the system will be driven to that vertex and the situation will persist. Clearly if vertex 1, "divorce or murder" must result; if vertex 16, we have the "marriage made in heaven", and the analysis had better start considering external input to the system to bring it back to earth.



Vertex #	Coordinate
1	-1 -1 -1 -1
2	-1 -1 -1 +1
3	-1 -1 +1 -1
4	-1 -1 +1 +1
5	-1 +1 -1 -1
6	-1 +1 -1 +1
7	-1 +1 +1 -1
8	-1 +1 +1 +1

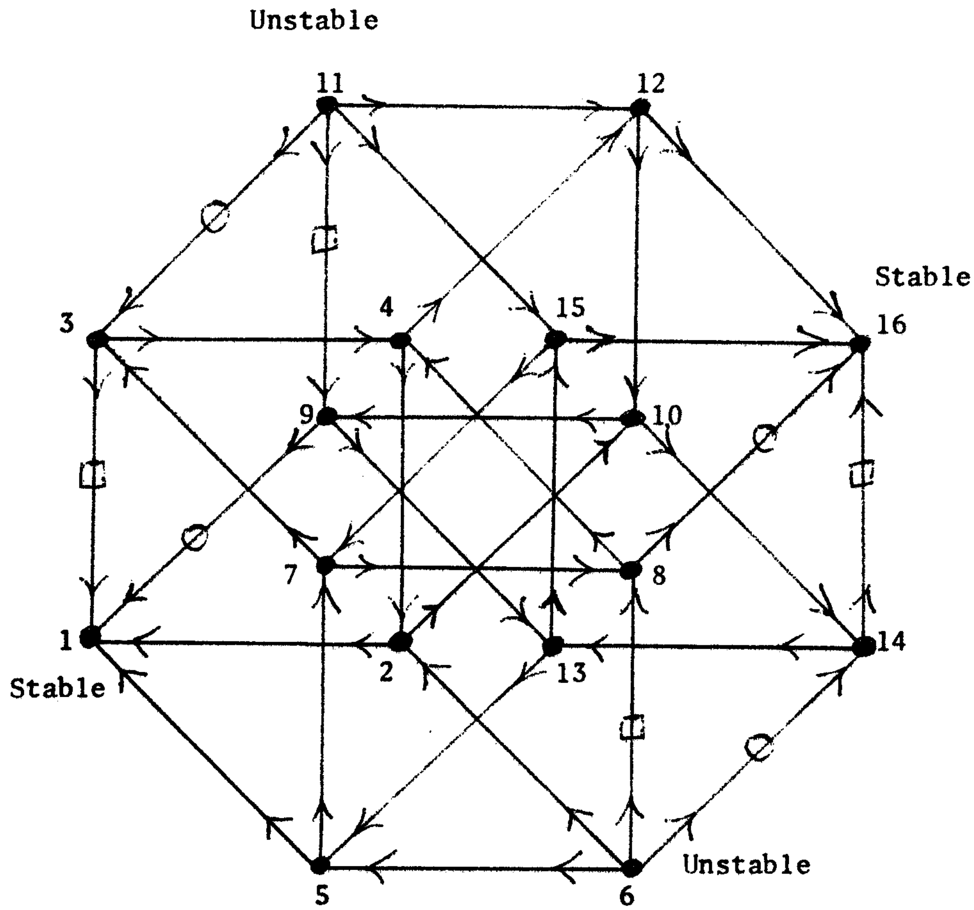
Vertex #	Coordinate
9	+1 -1 -1 -1
10	+1 -1 -1 +1
11	+1 -1 +1 -1
12	+1 -1 +1 +1
13	+1 +1 -1 -1
14	+1 +1 -1 +1
15	+1 +1 +1 -1
16	+1 +1 +1 +1

Figure 10 Two dimensional representation of tesseract edge direction Phase Space I System is either weakly or strongly coupled, man dominant, Cases 1 and 2, Appendix C-7.



For vertex numbering and edge symbols see Figure 10.

Figure 11 Two dimensional representation of tesseract edge direction Phase Space II. This is a weakly coupled system, neither person dominant, both introverts. Each vertex is a saddle point with two stable and two unstable edges. Case 3, Appendix C-7.

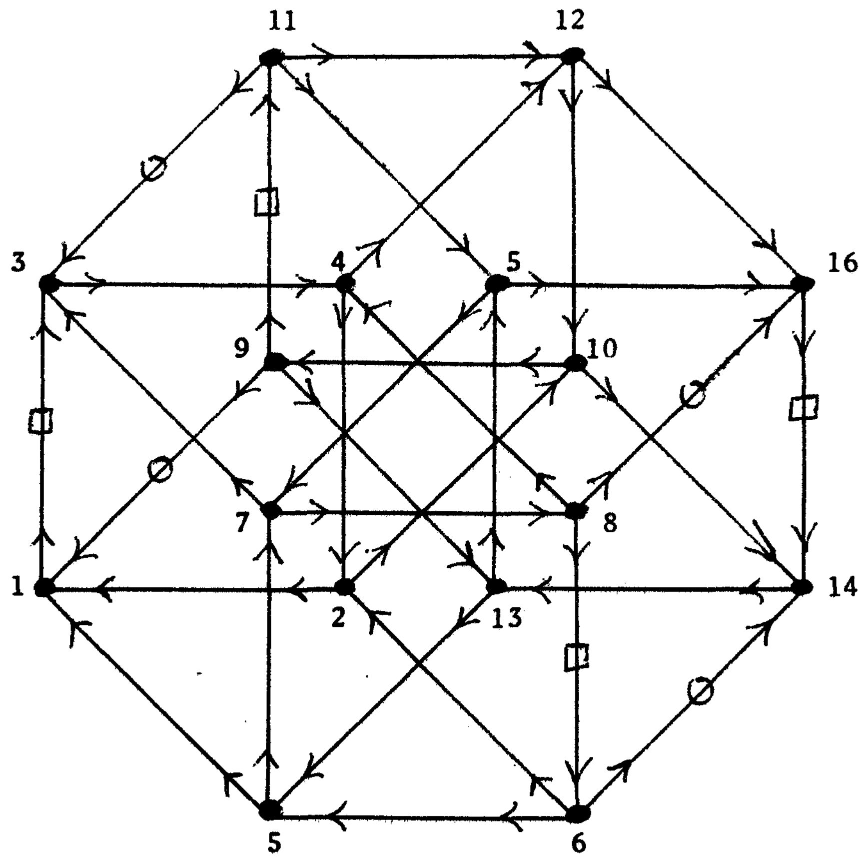


For vertex numbering and edge symbols see Figure 10.

Figure 12 Two dimensional representation of tesseract edge direction Phase Space III

This is a strongly coupled system with each person most affected by the output of the other person, Case 4, Appendix C-7.

It is only in this case where there are two completely unstable vertices, 6 and 11, and two completely stable vertices, 1 and 16.



For vertex numbering and edge symbols see Figure 10.

Figure 13 Two dimensional representation of tesseract edge direction Phase Space IV

The woman is dominant in respect to output effect. The system can be either weakly or strongly coupled, Cases 5 and 6, Appendix C-7. Vertices 1,3,14,16 each have three stable edges and Vertices 6,8,9,11 each have three unstable edges.

APPENDIX C-15 SUMMARY OF PHASE SPACE ANALYSIS WITH GRAPHS OF TOPOLOGICALLY DISTINCT CASES

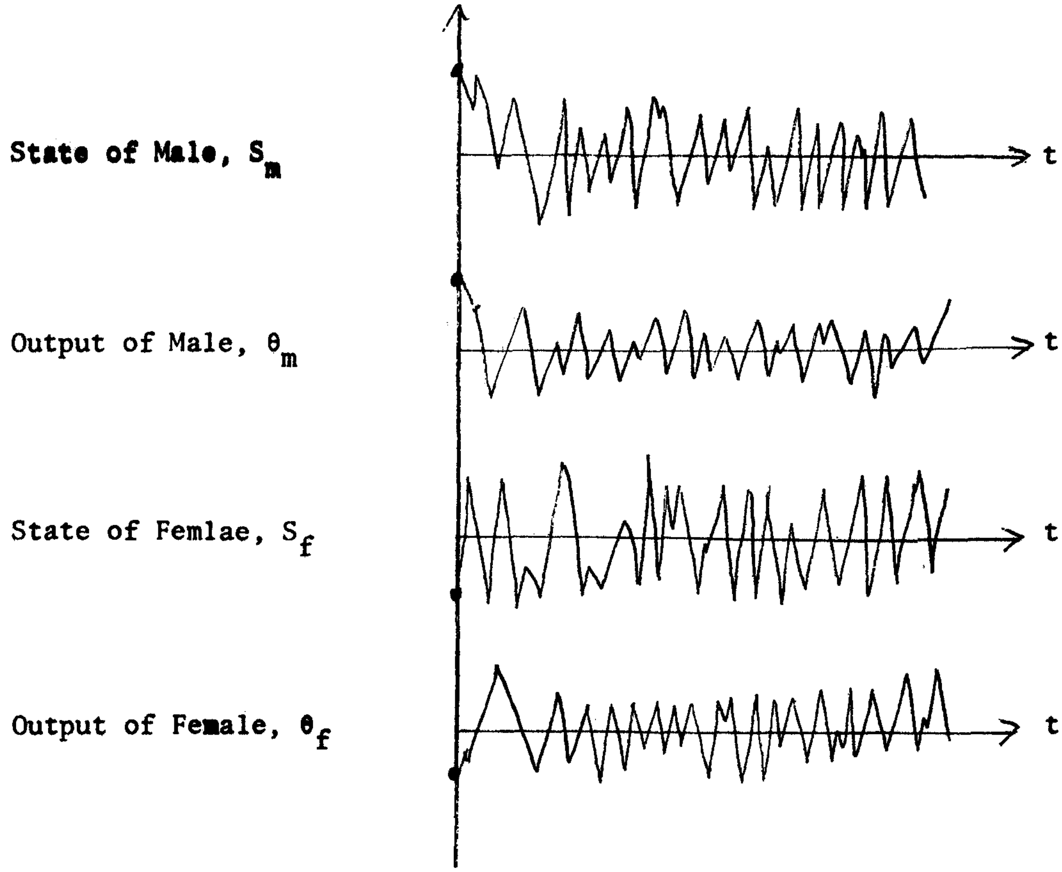


Figure 14 S_m, θ_m, S_f, θ_f as functions of time.

The above figure represents 500 time units, plotted by 10's. This graph illustrates the sort of real life behavior that can occur starting from an arbitrary set of initial conditions. Such realistic behavior is hard to analyze from a time plot alone. But with the phase space topology of the system at hand (in this case a weakly coupled system of two introverts), and the knowledge that every behavior pattern is a combination of fundamental modes which can be depicted, the typical variable behavior pattern can be understood.

Case Number	Description Appendix C-7	Set of a_{ijs}	Direction Edges At Vertices	Examples of Local Behavior at Origin	
				Eigenvalues	Eigenvectors
1	strongly coupled man dominant	see	Figure 10	± 1 $\pm 2i$	2 real 2 complex
2	weakly coupled man dominant	appendix	Figure 10	$\pm 2i$ $\pm\sqrt{38}\ i$	2 pairs of complex
3	weakly coupled introverts	C-12	Figure 11	$\pm 2i$ $\pm\ i$	2 pairs of complex
4	strongly coupled extroverts	for	Figure 12	± 1 $\pm 2i$	2 real 2 complex
5	strongly coupled woman dominant	a	Figure 13	± 1 $\pm\sqrt{6}\ i$	2 real 2 complex
6	weakly coupled woman dominant	table	Figure 13	$\pm 1i$ $\pm\sqrt{6}\ i$	2 pairs of complex

Figure 29: Summary of Phase Space Analysis of all Cases

(continued on next page)

Case Number	Example of Analysis		
	Eigenvalue	Eigenvectors or Planes of Oscillation	Figure Number for Small Motion Behavior
1	-1	(-1,1,-3,3)	5
	$+1$	(1,1,3,3)	4
	$\pm 2i$	(-1,0,2,0), (0,-1,0,2)	15
2	$\pm 2i$	(0,1,0,4), (1,0,8,0)	16
	$\pm\sqrt{38}\ i$	(2,0,-1,0), (0,-4,0,1)	16
3	$\pm 2i$	(1,0,-2,0), (0,-4,0,1)	2
	$\pm\ i$	(1,0,1,0), (0,1,0,1)	3
4	$+1$	(1,1,1,1)	17
	-1	(-1,1,-1,1)	17
	$\pm 2i$	(2,0,-3,0), (0,-2,0,3)	18
5	1	(2,4,3,3)	19
	-1	(-2,4,-3,3)	19
	$\pm\sqrt{6}\ i$	(1,0,-2,0), (0,-1,0,1)	19
6	$\pm\ i$	(1,0,1,0), (0,2,0,1)	20
	$\pm\sqrt{6}\ i$	(-3,0,2,0), (0,-3,0,1)	20

Table 29 continued: Summary of Phase Space Analysis Cases

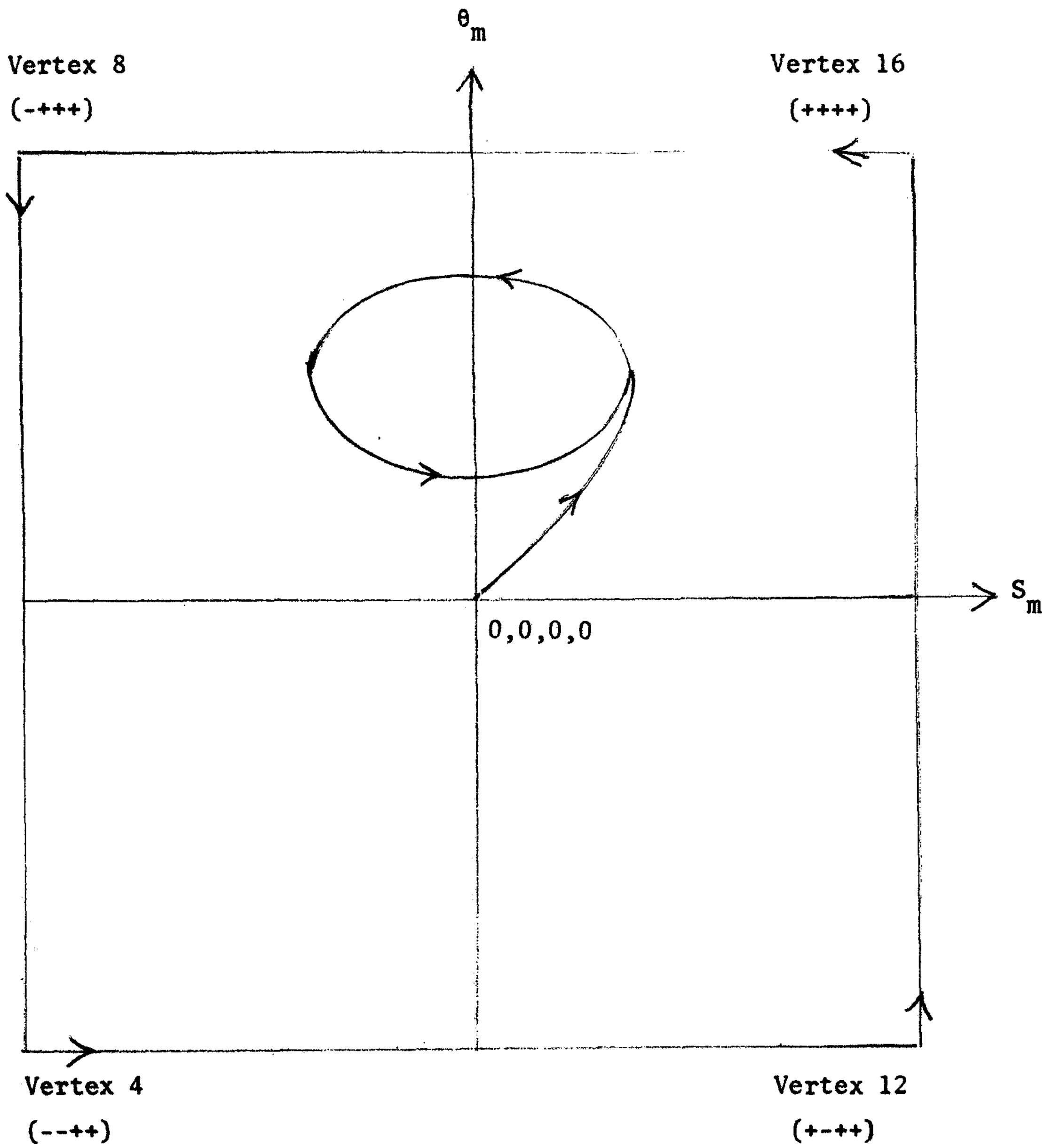


Figure 15 A strongly coupled system, male dominate, in the neighborhood of the origin, Case 1. Corresponding to eigenvalues ±2i, there should be a pure oscillatory mode in the neighborhood of the origin in the plane spanned by the real vectors (-1,+1,-3,+3) and (1,1,3,3). However, the unstable mode corresponding to the real eigenvalues +1 apparently dominates the oscillatory mode, and this sample behavior trajectory differs little from the critical unstable trajectory shown in Figure 4 for this system.

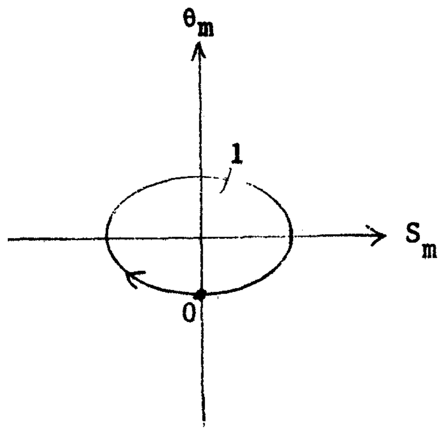


Figure 16-a Male Cycle

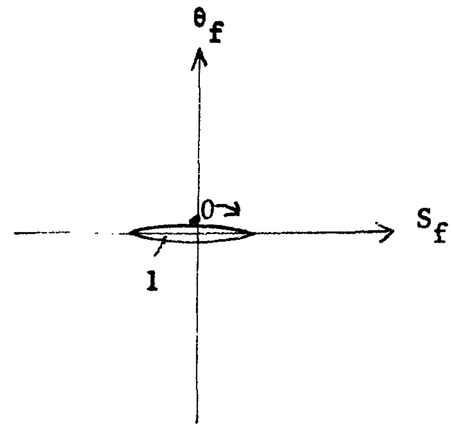


Figure 16-b Female Cycle

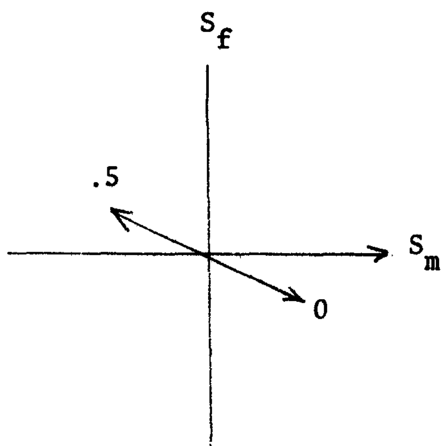


Figure 16-c States Compared

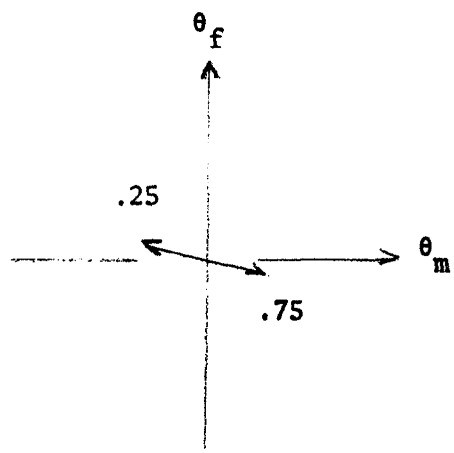


Figure 16-d Outputs Compared

Figure 16 A male dominated, weakly coupled, system in the neighborhood of the origin. Figures a, b, c, d: out-of-phase oscillation of frequency $\sqrt{38}$, and plane of oscillation spanned by (2,0,-1,0) and (0,-4,0,1). This is Case 2.

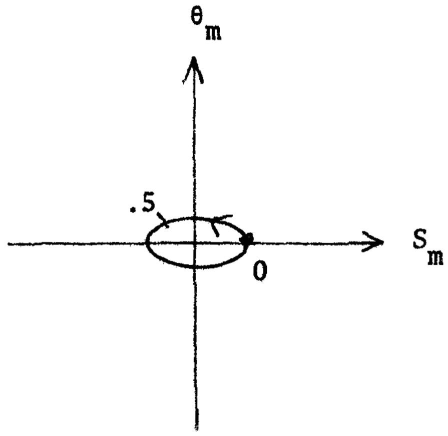


Figure 16-e Male Cycle

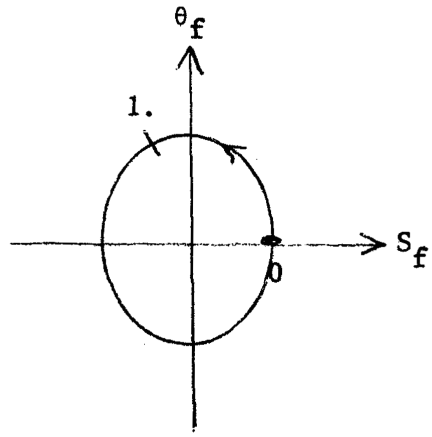


Figure 16-f Female Cycle

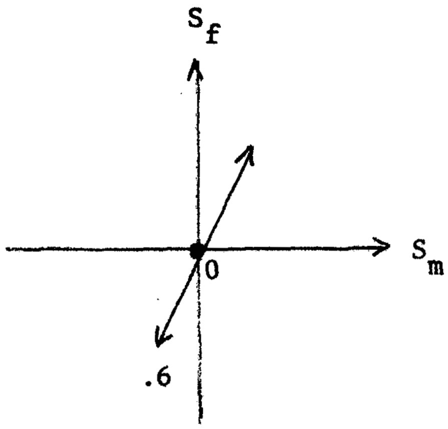


Figure 16-g States Compared

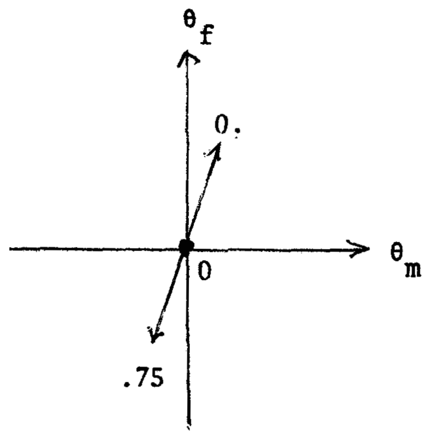


Figure 16-h Outputs Compared

Figure 16 A male dominated, weakly coupled, system in the neighborhood of the origin, Case 2. Figures e, f, g and h illustrate an in-phase oscillation of frequency 2 and plane of oscillation: (0,1,0,4), (1,0,8,0).

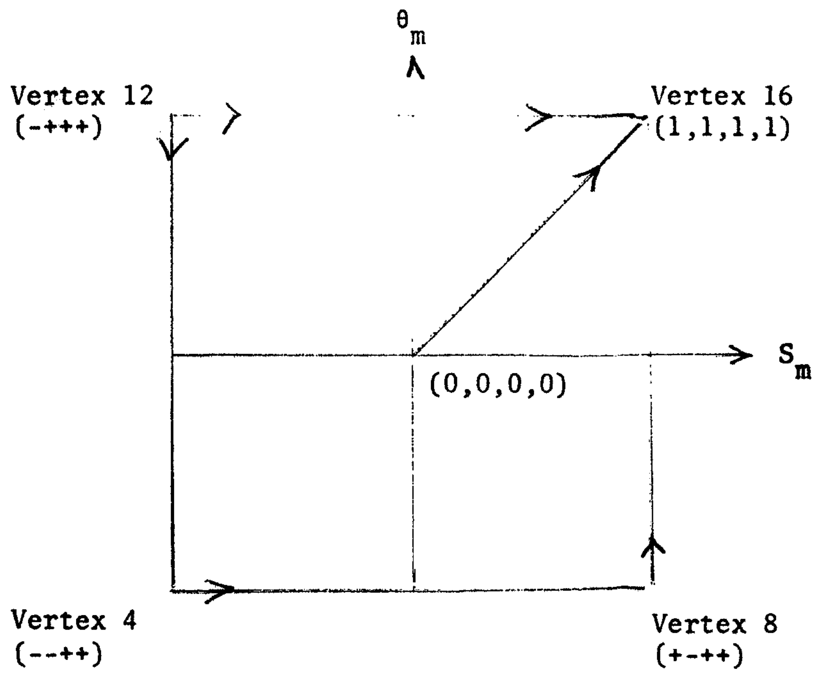


Figure 17-a Trajectory of Male

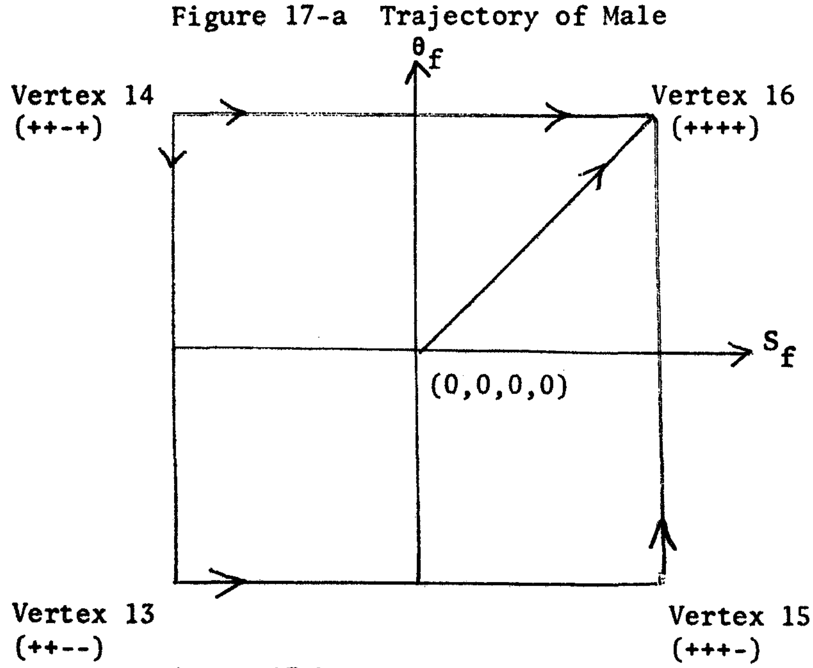


Figure 17-b Trajectory of Female

Figure 17 A strongly coupled system of extroverts in the neighborhood of the origin. In Figure 17 a, b the trajectory goes to the stable vertex 16 along the unstable eigenvector (1,1,1,1) where $\lambda = +1$. This is Case 4.

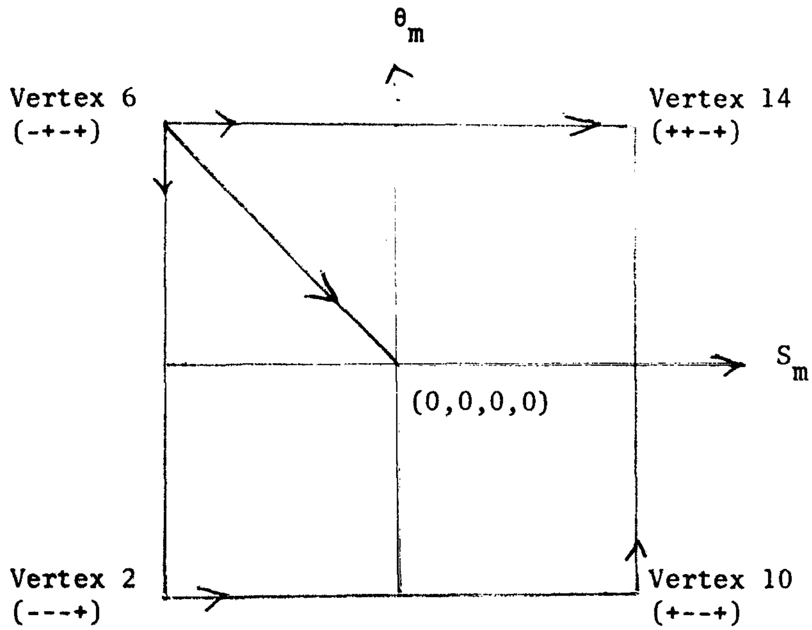


Figure 17-c Male Trajectory

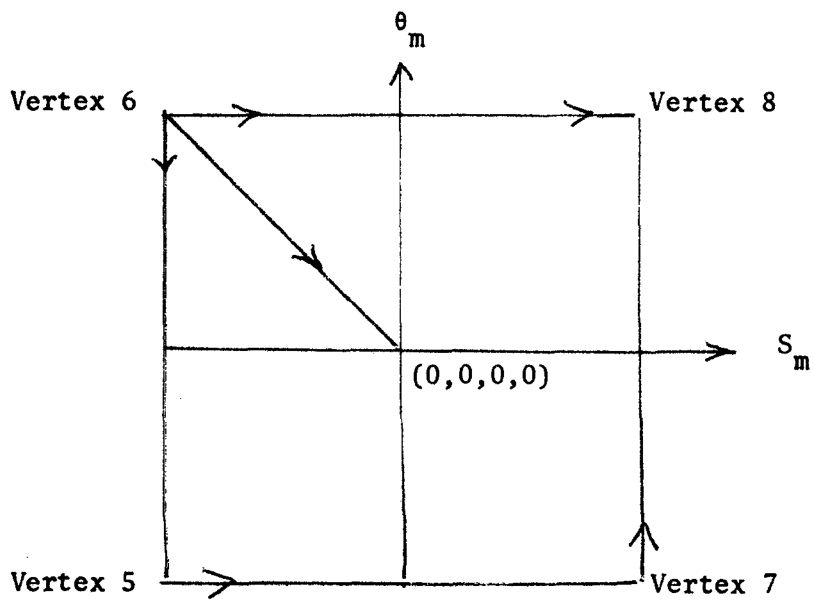


Figure 17-d Female Trajectory

The other real eigenvalue in this system, Case 4, of strongly coupled interaction is -1. The stable eigenvector (-1,1,-1,1) approaches the origin from the direction of vertex 6, as shown in Figures c and d.

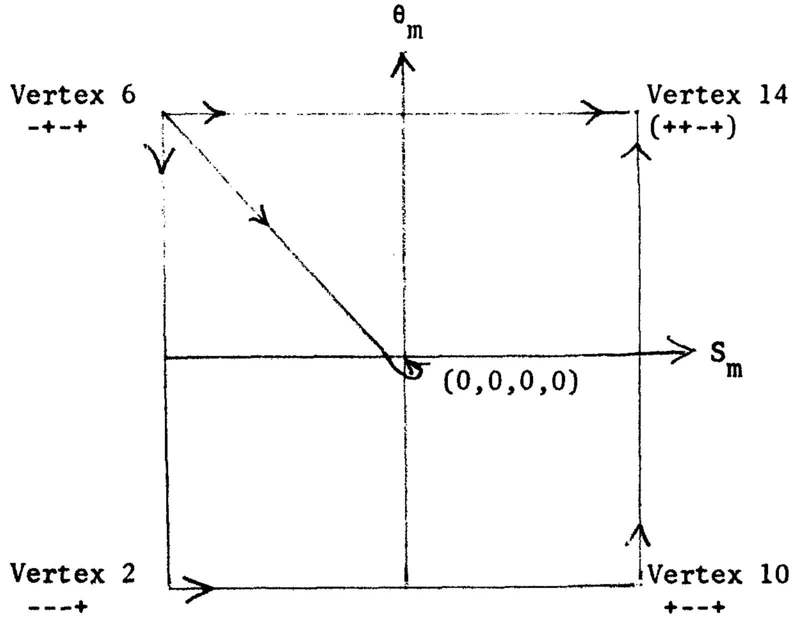


Figure 18-a Male Trajectory

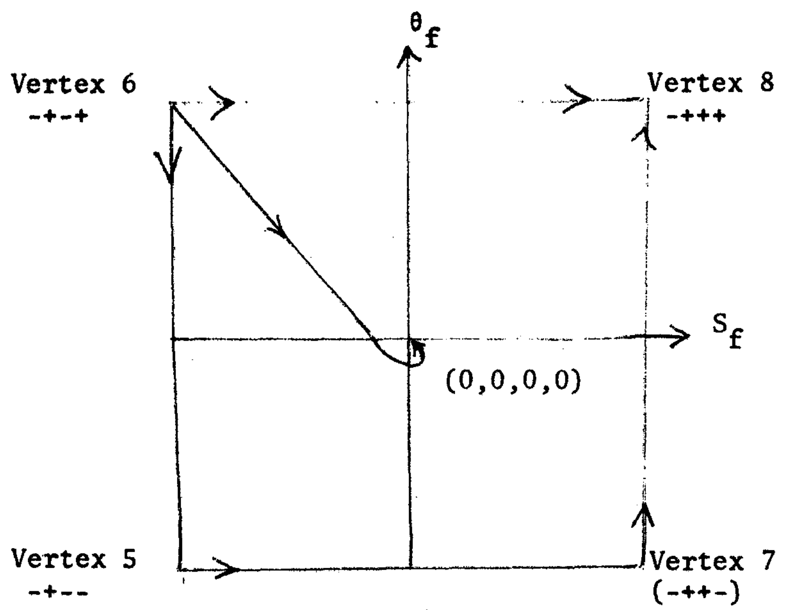


Figure 18-b Female Trajectory

Figure 18 Behavior of a strongly coupled system of extroverts, Case 4. Coming from the unstable vertex 6, the critical orbit spirals into the origin, with oscillatory behavior of frequency 2 cycles per unit time, parallel to the plan (2,0,-3,0), (0,-2,0,3).

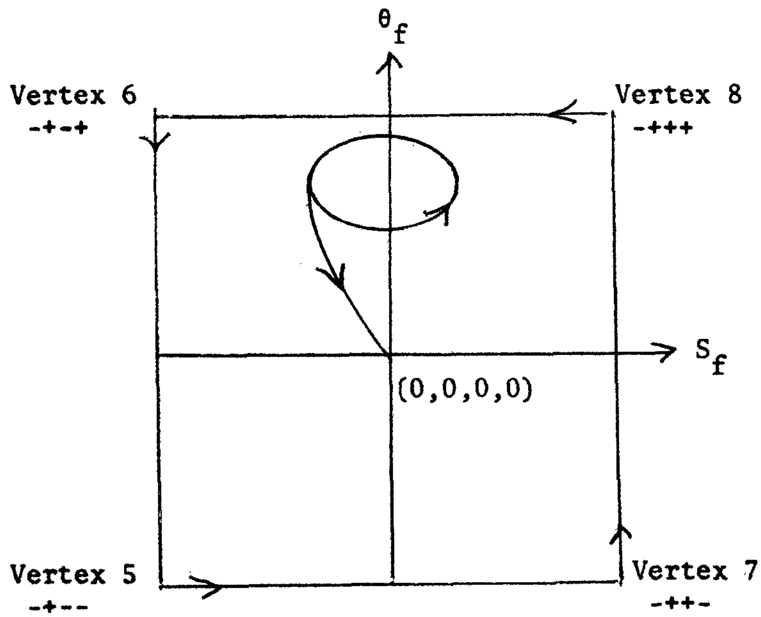


Figure 19-a Woman In Unstable Limit Cycle

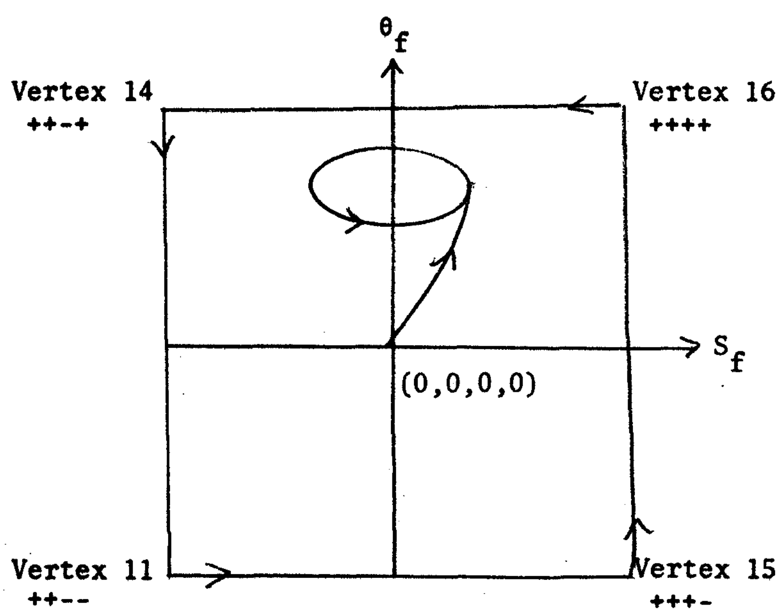


Figure 19-b Woman In Stable Limit Cycle

Figure 19 A strongly coupled system, woman dominate, in the neighborhood of the origin, Case 5. In Figure 19-a the trajectory rapidly approaches the plane $S_m = -1$, $\theta_m = 1$, along the stable eigenvector (-2,4,-3,3), $\lambda = -1$. Figure 19-b is the plane $S_m = 1$, $\theta_m = 1$ (happy man with positive output); the woman's trajectory is along the unstable eigenvector (2,4,3,3), $\lambda=+1$, to a stable limit cycle in the aforementioned plane.

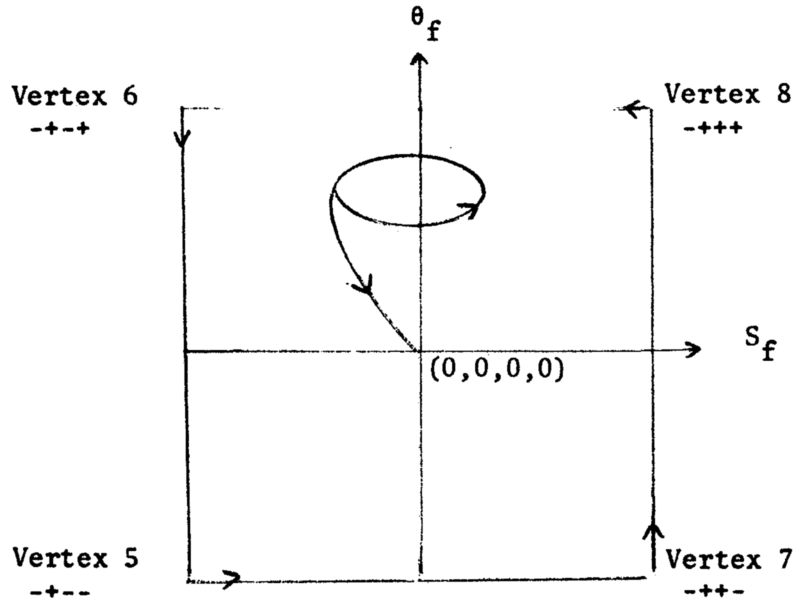


Figure 19-c A strongly coupled system, woman dominant, in the neighborhood of the origin. Corresponding to eigenvalues $\pm\sqrt{6}\,i$, there should be a pure oscillatory mode in the neighborhood of the origin in the plane spanned by the real vectors (2,4,3,3) and (-2,4,-3,3). However, the unstable mode corresponding to the real eigenvalue +1 apparently dominates the oscillatory mode, and this sample behavior trajectory differs little from the critical unstable trajectory shown in Figure 19-a for this system, Case 5.

Note that in the cases of a strongly coupled system: if there is one dominant person, (cases 1 and 5) he tends to go into a limit cycle while the other person approaches a limiting condition; if both persons are extroverts (case 4) each approaches a limiting condition.

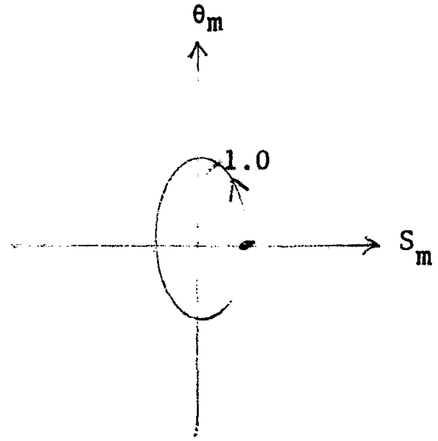


Figure 20-a Male Cycle

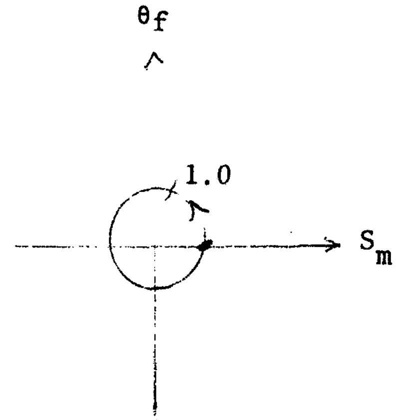


Figure 20-b Female Cycle

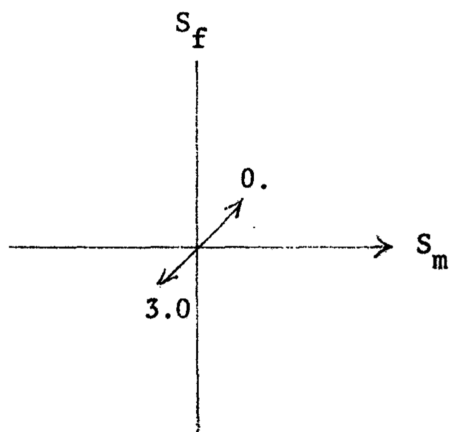


Figure 20-c States Compared

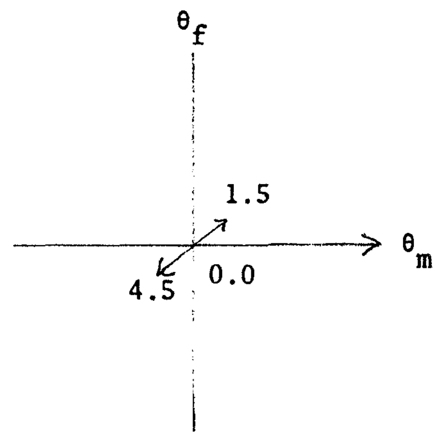


Figure 20-d Outputs Compared

Figure 20 A weakly coupled system, female dominate, in the neighborhood of the origin. Figures 20 a, b, c and d: in-phase oscillation of frequency 1 cycle per unit time in the plane spanned by (1,0,1,0), (0,2,0,1). This is Case 6. Note that in a weakly coupled system, dominated by one person, there is oscillation in the neighborhood of the origin; it is in the strongly coupled systems that one or both persons approach (or come from) a vertex.

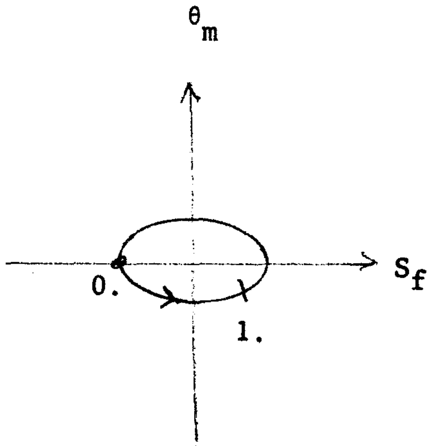


Figure 20-e Male Cycle

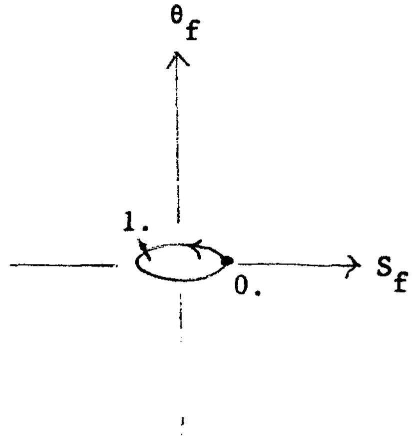


Figure 20-f Female Cycle

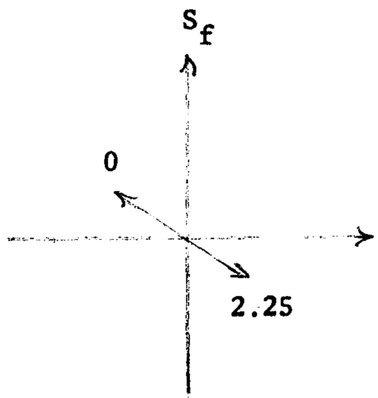


Figure 20-g States Compared

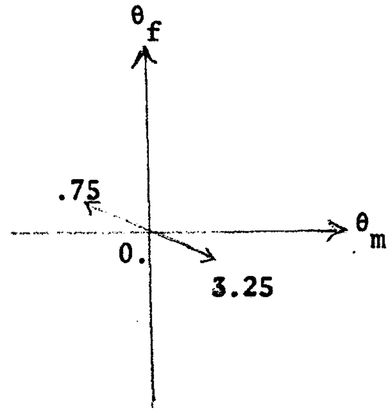


Figure 20-h Outputs Compared

Figure 20 continued: A weakly coupled system, female dominate, in the neighborhood of the origin, Case 6. Figures 20 e, f, g and h: out-of-phase oscillation of frequency $\sqrt{6}$ cycles per unit time in the plane spanned by (-3,0,2,0), (0,-3,0,1).

APPENDIX C-16 FLOW CHART CONTINUOUS SYSTEM

A simplified flow chart using FORTRAN for the continuous model is shown in Figure 21. The continuous system is, also, modeled in CSMP. The FORTRAN MODEL and CSMP, both simulations, used Fourth Order Runge-Kutta integration. The FORTRAN decks for both forward and backward runs were checked against trigonometric tables.

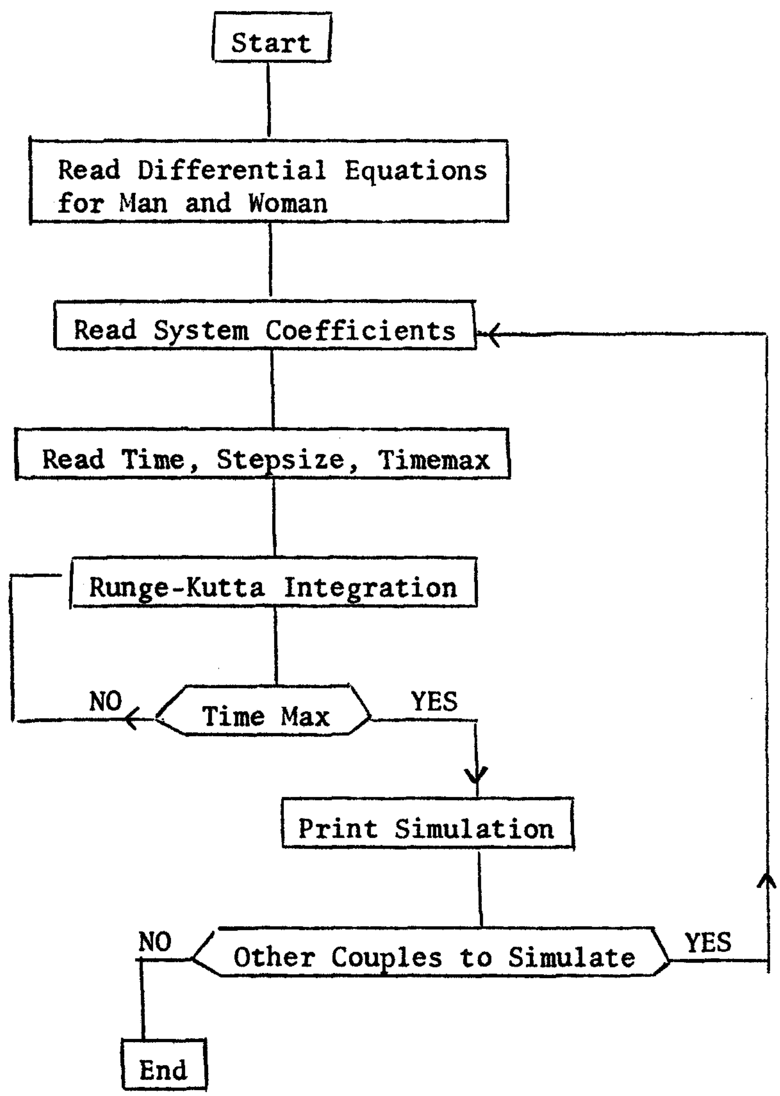


Figure 21
Simplified Flow Chart Continuous System

APPENDIX C-17 COMPUTER OUTPUT OF CONTINUOUS SYSTEM

SOCIOCYBERNETICS A SYSTEM ANALYSIS OF HUMAN RELATION-CONTNUOUS STATE-GENESIS MODEL
HENRY WARREN KUNCE, MAY 6,1971 ,UNIVERSITY OF MIAMI

PHASE SPACE ANALYSIS NUMBER 30 AT CRITICAL POINT: -1.000, 1.000, -1.000, -1.000

>>VARIABLE COEFFICENTS:A12= 2.0 A14= 1.0 A21= 1.0 A32= 2.0 A34= 3.0 A43= 1.0

EIGENVALUE AT ORGIN =

TIME	MAN STATE	MAN OUTPUT	WOMAN STATE	WOMAN OUTPUT	
	-1.000	1.000	-1.000	-1.000	<<REPRESENTS CRITICAL POINT
0.000	-0.993	0.993	-0.990	-0.990	<<< STARTING POINT FOR SIMULATION
0.250	-0.997	0.994	-0.398	-0.994	
0.500	-0.999	0.973	-0.262	-0.996	
0.750	-1.000	0.956	0.726	-0.995	
1.000	-1.000	0.929	0.856	-0.992	
1.250	-1.000	0.885	0.921	-0.987	
1.500	-1.000	0.817	0.960	-0.979	
1.750	-1.000	0.716	0.982	-0.965	
2.000	-1.000	0.571	0.994	-0.943	
2.250	-1.000	0.379	0.998	-0.908	
2.500	-1.000	0.149	1.000	-0.853	
2.750	-1.000	-0.101	1.000	-0.769	
3.000	-1.000	-0.337	1.000	-0.646	
3.250	-1.000	-0.538	1.000	-0.477	
3.500	-1.000	-0.692	1.000	-0.262	
3.750	-1.000	-0.801	1.000	-0.019	
4.000	-1.000	-0.874	1.000	0.227	
4.250	-1.000	-0.922	0.999	0.447	
4.500	-1.000	-0.952	0.995	0.623	
4.750	-1.000	-0.973	0.967	0.752	
5.000	-1.000	-0.982	0.756	0.834	
5.250	-0.999	-0.989	-0.114	0.860	
5.500	-0.996	-0.993	-0.801	0.819	
5.750	-0.985	-0.996	-0.924	0.727	

Table 30

Simulation of weakly coupled system, each most effected by own output at Vertex 5, starting at Vertex 5 where the man is sad giving good outputs, and the woman is sad giving poor outputs.

```
MAN'S INTERNAL STATE OVER TIME          SOCIOCYBERNETICS            PAGE    2

                           MINIMUM             Z1      VERSUS TIME              MAXIMUM
                         -2.6918E-01                                           2.9716E-01
 TIME            Z1          I                                                  I
1.2750E 01   1.3560E-01   -----------------------------------+
1.3000E 01   6.2140E-02   -----------------------------+
1.3250E 01  -1.5580E-02   ----------------------+
1.3500E 01  -9.1462E-02   ---------------+
1.3750E 01  -1.5949E-01   ---------+
1.4000E 01  -2.1435E-01   ----+
1.4250E 01  -2.5177E-01   -+
1.4500E 01  -2.6851E-01   +
1.4750E 01  -2.6228E-01   +
1.5000E 01  -2.3195E-01   ---+
1.5250E 01  -1.7815E-01   --------+
1.5500E 01  -1.0446E-01   --------------+
1.5750E 01  -1.8177E-02   ----------------------+
1.6000E 01   7.0380E-02   -----------------------------+
1.6250E 01   1.5028E-01   -------------------------------------+
1.6500E 01   2.1281E-01   ------------------------------------------+
1.6750E 01   2.5293E-01   ----------------------------------------------+
1.7000E 01   2.6894E-01   -----------------------------------------------+
1.7250E 01   2.6138E-01   ----------------------------------------------+
1.7500E 01   2.3216E-01   --------------------------------------------+
1.7750E 01   1.8413E-01   ----------------------------------------+
1.8000E 01   1.2121E-01   ----------------------------------+
1.8250E 01   4.8386E-02   ----------------------------+
1.8500E 01  -2.8430E-02   ---------------------+
1.8750E 01  -1.0290E-01   --------------+
1.9000E 01  -1.6894E-01   --------+
1.9250E 01  -2.2128E-01   ----+
1.9500E 01  -2.5573E-01   -+
1.9750E 01  -2.6918E-01   +
2.0000E 01  -2.5945E-01   +
```

Table 31

Man's Internal State in strong coupled system
Case 1, man dominant starting at the origin.

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VITA

Henry Warren Kunce was born April 18, 1925 in St. Louis, Missouri. He grew up in suburban Kirkwood, graduating from high school in 1942. He enrolled as a civil engineering student at Washington University in St. Louis, but in his junior year gave up a deferment to enter the army during World War II. The time in service was also a time of question asking: why do men build bridges only to destroy them? There must be a way to build bridges between men of diverse races and cultures; that problem came to seem to him more basic than the building of a suspension bridge. Mr. Kunce returned to Washington University after V-J Day and completed his work for an A.B. Degree with a major in mathematics in 1946. Three years of graduate study followed at McCormick Theological Seminary in Chicago from which he received the B.D. Degree in 1949.

The Presbyterian Congregation he first served was in Galion, Ohio. He returned to St. Louis and served a suburban church from 1953-1961, after which he developed a new congregation in Kansas City, Missouri. He came to Miami in 1965 to organize the first planned suburban interracial Presbyterian Church in the nation. During the twenty years as a parish minister, he continued graduate studies and participated in professional institutes: Presbyterian Institute of Industrial Relations, New York City (1949); Washington University, St. Louis (1957-59); Johnson C. Smith University, Charlotte, North Carolina (1965); University of Omaha (1963); Institute of Advance Pastoral Studies, Detroit (1961); Krisheim Institute, Philadelphia (1967).

The motivational factor in his ministry was that the truth would make men free. The application of this in human relations is evident. The parish church might have been the laboratory for experimental development in human relations, and the nucleus for such development in community life, but his long dormant early training in the physical sciences led Mr. Kunce to seek new tools to apply to those problems which seem to him so basic.

A whole new tool had been successfully applied in the physical sciences: cybernetics. Was it possible that cybernetics could be used in the ultimate enrichment of human relations? Man's response to other men and the raising tension in the world made Mr. Kunce wonder if we know enough about human interactions to survive. A saddle point had been reached; he enrolled in the University of Miami's School of Engineering in 1969 for graduate studies in Systems Analysis.

As a young man, he departed from his mathematical and engineering training to enter the ministry as a means of human-bridge building. Now he seeks to take more than twenty years' experience in the human relations field, and use the sophisticated tools of modern cybernetics to build a bridge with the dynamic analytical tools of the physical scientist in human relations and the concerns of the behaviorial scientist.

Married to Miss Avon Estes in 1948, he lives with her and their five children at 5025 S. W. 74th Terrace, Miami, Florida.